MEKELLE UNIVERSITY

DEPARTMENT OF ECONOMICS

COLLEGE OF BUSINESS AND ECONOMICS

FACTORS AFFECTING HOUSEHOLD DECISION TO ADOPT ROOF WATER HARVESTING PRACTICES AS A SOURCE OF DOMESTIC WATER SUPPLY IN MEKELLE, ETHIOPIA

BY

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A THESIS

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DECLARATION

This is to certify that this thesis entitled " Factors affecting household decision to adopt roof water harvesting practices as a source of domestic water supply in Mekelle" submitted in partial fulfillment of the requirements for the award of the degree of MSc., in Development Policy Analysis to the College of Business and Economics, Mekelle University, through the Department of Economics, done by._Mr. .Araya Abraha, Id.No.CBE/PE228/03 is an authentic work carried out by him/her under my guidance. The matter embodied in this project work has not been submitted earlier for award of any degree or diploma to the best of my knowledge and belief.

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CERTIFICATION

As member of the Board of Examiners of the MSc Thesis Open Defense Examination, we certify that we have read, evaluated the Thesis prepared by Araya Abraha and examined the candidate. We recommended that the Thesis be accepted as fulfilling the Thesis requirement for the Master of Science Degree in Economics (Development Policy Analysis).

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ABSTRACT

The population size of Mekelle grows very fast while water supply remains inadequate to satisfy the demand. Despite the progress Mekelle Water Supply Service Office (MWSSO) made so far, there is still the challenge of providing adequate and persistent pure water supply in the city. The objective of this study is, therefore, designed to analyze factors influencing the adoption of Domestic Roof Water Harvesting (DRWH) practices using a binary logit model. The results of the study are based on data collected from a survey of 120 households which are selected using purposive and stratified sampling techniques to select enumeration areas and sampling unit (sample strata) respectively. And 30 sample respondents are selected using purposive sampling from each stratum. In addition 20 non household water users are selected purposively for focus group discussion. The binary logit model used a total of 11 explanatory variables. Out of which 8 variables were significant to affect household decision to adopt DRWH practices. These are age, monthly income, perception towards quality & reliability of existing water supply, social responsibility and attitude towards importance of roof water harvesting, house ownership and affordability of the technology. Therefore, this study focuses on the extent of adopting DRWH as an alternative source of fresh water in the face of increasing water scarcity since it is remaining untapped resource. It also aims at filling the gap of research on identifying factors influencing household's decision to participate in DRWH and it will enable policy makers to have adequate information for the attainment of the implementation of the technology.

Key words: roof water harvesting, technology adoption, logit model, potable water, Mekelle

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ABBREVIATIONS

ARPN	Asian Research Publication Network
BoFED	Bureau of Finance and Economic Development
CC	Contingency Coefficient
DRWH	Domestic Roof Water Harvesting
DTU	Development Technology Unit
EA	Enumeration Area
FAO	Food and Agriculture Organization
IFPRI	International Food Policy Research Institute
LPM	Linear Probability Model
MLE	Maximum Likelihood Estimation
MWR	Ministry of Water Resource
MWSSO	Mekelle Water Supply Service Office
RWH	Rain Water Harvesting
VIF	Variance Inflating Factor
WRDF	Water Resource Development Fund

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1. INTRODUCTION

1.1Background

Water is the major substance on the earth, covering more than 70% of its surface. Out of the total volume of water available on the surface of the earth, only 2 percent (over 28,000,000 km^3) is fresh water (Dwivedi. A.K et al.,2009). Water is a prerequisite for life and without it there will be no living thing. Fresh water is used for the purpose of human use, industries and agriculture. Access to and use of safe drinking water can make an immense contribution to health, productivity, and social development (IFPRI, 2010**).** However, population growth; pollution and climate change are likely to produce a drastic decline in the amount of water available per person in many parts of the developing world. As a result, millions of people throughout the world do not have access to clean water for domestic purposes. According to WHO/UNICEF (2000), cited by Dwivedi. and Bhadauria, 2009), 1.1 billion people lack access to improved water supply due to population growth and rapid urbanization. This number will likely rise rapidly in the coming years unless serious measures are undertaken to stem the tide. Its availability remained a serious issue in both urban and rural areas in developing as well as developed countries (Tripathi and Pandey, 2005; Dwivedi and Bhadauria, 2009).This led the international community to set goal in the United Nations Millennium Declaration to reduce by half the population with no access to safe water by 2015.

In many parts of the world, conventional piped water is either absent, unreliable or too expensive. Therefore, rainwater harvesting (RWH) has been identified as a valuable alternative or supplementary water resource, along with more conventional water supply technologies (Janette W. et. al, 2006).

RWH is primary source of fresh water and can be broadly defined as a collection and concentration of the rain for productive purposes like drinking, food making, cloth washing, back yard vegetables, permanent fruit production and livestock. But most of the rainwater from the roof top of the city goes back to rivers without being properly used. And, the rapid urbanization has further aggravated the urban runoff problem which causes erosion and land degradation (FAO, 2000).

People in some parts of the world where water shortage exists have a better understanding of the way to mix domestic roof water harvesting (DRWH) with other water supply options, in which it is usually used to provide full coverage in the wet season and partial coverage during the dry season as well as providing short-term security against the failure of other sources (Thomas and Martinson, 2007).

In this case, the application of an appropriate RWH technology can make possible utilization of rainwater as a valuable and, in many cases, necessary water resource (Jose P., 2000). Therefore, DRWH is a simple low-cost technique that requires minimum specific expertise or knowledge and offers many benefits.

According to Ngigi (2003), the application of RWH technique, although potentially high, is still traditional and low in Ethiopia. The reason that DRWH is rarely considered and becomes traditional is often simply due to lack of information on technical and financial feasibility, inadequate strategies, human resources and policies for its promotion.

Ethiopia is one of the countries that are at the very low stage of development and is currently facing several social and economic problems. Its cities are confronted mainly with extensive poverty, which is characterized, among other things, by environmental problems and underdevelopment of physical infrastructure such as low access to health, education, water and low level of investment in social services (Medhin, 2006)

In Mekelle, the regional capital city of Tigrai, ground and surface water supplies are of inadequate quantity and quality. This is because there are very little potentials; therefore collection of rainwater is only a practical solution very simple and user friendly to this serious problem.

In general, there is a traditional (informal) practice of domestic roof water harvesting in Mekelle as well as in other parts of Ethiopia. DRWH has the potential to fill part of the household fresh water demand in Mekelle where other sources of fresh water have been limited. But so far its adoption has been very limited for various reasons.

Thus, this study is undertaken in Mekelle city, to identify social, economical, institutional and technological factors that can affect households to participate in RWH practices and also to generate information for policy makers and practitioners.

1.2. Statement of the problem

Adequate and safe water supply is one of the basic urban services, which highly influence economic progress of towns and the health of their dwellers (Yimer, 1992). This means that water resource availability, or its lack is linked to economic and social progress, which suggests that development is strongly influenced by water resource availability and management (Sullivan, 2002)

Various studies have been made on water service coverage of different African countries. Accordingly, a study on water supply coverage synthesis in Ethiopia (Ministry of Health, 2011) stated that, Ethiopia's water supply coverage has reached 88 % based on getting 20 liters per person per day within 0.5km in urban areas. Though the coverage has shown considerable improvement over the last decade, it remains inadequate to fully satisfy the demand of safe drinking water of the population.

Sullivan (2002) stated that, 'without adequate and efficient water supplies, where there is water poverty, any measures to reduce income poverty are unlikely to be successful'. That is why the importance of adequate and safe water supplies for poverty reduction has attracted the attention of governments and different world organizations.

Though, DRWH technology will have the capacity and should be designed with the aim of raising the urban water supply coverage to satisfy the full demand along with other sources under use widely, the Ethiopian water resources management policy didn't point out anything about rainwater harvesting. Target established in the national water sector development program indicate that the national safe water supply coverage will be 96 percent by the end of 2016. So, It would be a challenging to the ministry to achieve its plan without considering one of the simplest and affordable technological option; DRWH system.

Recently, the government has started promoting and investing significant amount of money on rainwater harvesting for crop production and domestic water supply purposes, which is an encouraging step to attain the target.

In relation to the population growth, the population projection made by regional bureau of plan and finance, stated that the city's population is 272, 539 in 2012 with annual growth rate of 4.7%. Thus the daily water requirement of the city is 43,992 m^3 per day while the existing supply is 20,500 m^3 per day and average per capita water requirement is 161 liters per capita domestic consumption while the existing condition reveals 40 liters per capita domestic consumption (MWSSO, 2012). Therefore, this persistent shortage of water brings an increasing interest to low cost alternatives generally referred to as 'water harvesting' especially for DRWH which can be used for different purposes.

Adoption of RWH as a policy intervention can be part of the strategic national water supply, sanitation and hygiene program and universal access program to achieve the MDGs. In the long run, it is expected to benefit the population of the town in general and women in particular. A general improvement in health and eventually higher productivity of the population can be achieved as a result of provision of adequate and safe drinking water (WRDF, 2008).

The immediate output of this study is identifying different socio-economic and other factors affecting the adoption of RWH by providing adequate information towards increasing its exploitation. Sustainable availability of safe water supply in the required quality and quantity promotes the socio-economic development of the city in particular and the region in general. And investment is attracted and the city's socio-economic development brings structural change from traditional economic activity to modern scale business ventures.

Mekelle city is currently in a state of inadequate water supply and this affects the daily life of the citizen and other social, economic and political activities of the city. Besides, the quality of existing water supply is often poor and leads to continuing problems of health (WRDF, 2008). Hence, identifying the factors that contribute to the collection and use of rain water will have a great impact towards providing solutions that increase its exploitation and thereby improving quality and availability. Along with this, there are many researchers who conducted research on RWH for agricultural purposes in Ethiopia but as to my knowledge, no published study is available which assesses the socio-economic and other factors affecting the adoption of RWH as an alternative source of potable water supply in urban areas.

1.3. Objective of the study

The main objective of the study is to identify the major factors that influence household decision to adopt domestic roof water harvesting and its widespread use in Mekelle.

1.3.1 Specific objectives

- To analyze the influence of Socio- economic characteristics and technological factors on the adoption of domestic roof water harvesting practice in Mekelle
- To observe the extent of adoption of DRWH in Mekelle
- To examine the purpose to which rain water use is put in Mekelle.

1.4. Scope and Limitation of the Study

The study is carried out in Mekelle with principal concern of identifying key social, economic, attitudinal and technological factors that significantly influence the adoption of DRWH practices. Due to time and budget limitations and accessibility problems, the study was conducted only at mekelle, the capital city of the regional state of Tigrai. This is because Mekelle is characterized by inadequate water supply and there is also a growing demand for this service. Thus, the study tries to focus on the adoption of DRWH only from the existing water supply problem perspective. And adoption of DRWH is not a matter of leaving to the community to choose among alternative sources but it is the only low cost, user and environmental friendly technology that everyone has to adopt. Therefore, the study tries to identify factors influencing its adoption. However, the recommendations and policy implications drawn out of this study were possibly used in other locations having similar problems.

1.5 Significance of the study

The population of Mekelle is growing at an alarming rate. Its size is rapidly expanding towards the surrounding periphery. The urban economic activities (commercial and industrial) are expanding and creating an increasing demand for water supply (BoFED, 2011). “Growth in human population is creating an increasing demand for water, and if at the same time, standard of living is to rise, water consumption per capita is likely to rise” (Sullivan, 2002: 1196). These phenomena call for immediate efforts to improve the existing water supply and promote the adoption of DRWH technology to cope up with the increasing demand for water. Hence, to have complete information about the extent of DRWH practices and factors’ affecting its adoption is important. Thus, household units are the focus of this study.

The use of DRWH is important in areas of limited availability of fresh water like Mekelle, where available fresh water was scarce; identifying the factors that influence the collection and use of rain water have had a great impact towards making solutions that increase its exploitation. Moreover, it is intentioned to address that, policy has traditionally focused on increasing water supply by investing in large scale and centralized projects. But the importance of securing water supply necessitates that all options has to be explored. Finally, the results of this study were also having an impact on the academic community, regional government and policy makers and the public at large.

1.6 Organization of the study

This thesis is organized in to five chapters. Chapter one deals with background information, statement of problem, objectives, significance and scope of the study. Chapter two contains the review of literature which focuses on theoretical aspects of roof water harvesting, methodological review of technology adoption and empirical review on different socio-economic factors. Description of the study area, method of data collection, analysis, definition of variables and hypothesis statements are stated in chapter three. Chapter four is reporting the discussion of results and finally chapter five presents conclusion and recommendation of the study.

2. LITREATURE REVIEW

This chapter discusses theoretical review on concepts, definitions, historical perspectives, advantages and disadvantages of roof water harvesting. It also comprises countries' experiences, model explanation of adoption decision, empirical studies on adoption of technology and brief issues to be considered for a proper promotion and adoption of water harvesting activities across potential users.

2.1. Conceptual and Theoretical review

2.1.1. Concepts of roof water harvesting

Dwivedi (2009), mentioned that the human civilization, entirely depend upon rivers, lakes and ground water to fulfill their water demands. However rain is the ultimate source that feeds all these sources. The implication of rainwater harvesting is to make optimum use of rainwater at the place where it falls i.e. to conserve it without allowing it to drain away. Rainwater harvesting is an ancient technique enjoying a revival in popularity due to the inherent quality of rainwater. Rainwater is valued for its purity and softness. It has a nearly neutral pH[1], and is free from impurities such as salts, minerals, and other natural and man-made contaminants.

The basic source of all water on the earth is rainfall/precipitation, snow etc. About 70 Percent of the precipitation that reach on the land area is evaporated or transpired directly back to the atmosphere; 10 Percent socks in and becomes ground water, and 20 Percent runs off in to lakes, streams and rivers (Befekadu k., 2008).

Thus using DRWH system we can use the rainwater/rainfall before any of the losses mentioned in the above paragraph and avoid the difficult to regain it back by investing huge amount of money for pumping, construction of Dams or reservoirs, construction of purifications or treatment plants

[1] PH indicates the acidic nature of rain water as compared to surface and sub surface water sources. As a result, it is valued for its purity and softness.

and convey the stored water from head works to each house through various pipe size and length etc (Thomas. T, Martinson, D.B, 2003)

Indiscriminate exploitation of ground water and the decline in ground water level shave rendered many bore wells dry either seasonally or throughout the year. To overcome such a situation, bore wells and tube wells are now being drilled to greater depths, often tapping ground water from deep aquifers till then considered ‘static’. (www.arpnjournals.com, 2006)

Rainwater harvesting is a common practice in the countries and areas where the annual precipitation is high and pure drinking and usable water is scarce. All over the world, economical condition has prompted the low-income groups to harvest the rainwater for household and essential uses. Several countries of the world in different regions have showed the popularity of this method. (Janette W. et. al, 2006)

Butler et al (2011) suggested that rooftop rainwater harvesting for household purpose only represent a small part of the total water balances. In areas with significant variations in the annual rainfall pattern, the matching of water supply and water demand may be difficult. However, in terms of economic and human welfare it has a crucial role to play. Rainwater in many cases is the easiest to access, most reliable, and least polluted source. It can be collected and controlled by the individual household or community as it is not open to abuse by other users.

2.1.2 Definitions of domestic roof water harvesting

Different literatures define RWH as the collection, storage and subsequent use of captured rainwater as either the principal or as a supplementary source of water for both potable and non-potable applications to provide water for domestic, commercial, institutional and industrial purposes as well as agriculture, livestock, groundwater recharge purposes in both develop and developing countries. Usually rain water harvesting in developed countries is used for non potable uses such as Toilet flushing, laundry cleaning (washing machines), garden watering and car washing. While in developing world usually it is used for potable water such as drinking, food making and also for non potable purposes in rear cases.

According to Reij et al, (1993), water harvesting is usually employed as an umbrella term describing a whole range of methods of collecting and concentrating various forms of runoff (roof top runoff, overland flow, stream flow, etc) from various sources(precipitation, dew etc.) and for various purposes(domestic and non domestic uses).

2.1.3 History of Rain Water Harvesting

The history of rainwater harvesting systems Originated almost 5000 years ago in Iraq, rainwater harvesting is practiced throughout the Middle East, the Indian subcontinent, in Mexico, Africa as well as in Australia and United States. As the population of the world increased, irrigation, the most water consuming human activity, as well as domestic water usage increased, leading to a consequence of crisis of water supply in different region. Among other available alternative sources for water supply, rainwater harvesting has become the most economic solution for the water crisis (Boers and Ben-Asher, 1982).

Gould. J. & Nissen-Peterson (1999) also provide a detailed history of rainwater harvesting systems. The authors state that, whilst the exact origin of RWH has not been determined, the oldest known examples date back several thousand years and are associated with the early civilizations of the Middle East and Asia. In India, evidence has been found of simple stone-rubble structures for impounding water that date back to the third millennium BC (Agarwal & Narain, 1997). Similar practice in Sardinia, from the 6th century BC onwards, many settlements collected and used roof runoff as their main source of water (Richard R., 2000). Many Roman villas and cities are known to have used rainwater as the primary source of drinking water and for domestic purposes. Besides, there is evidence of the past utilization of harvested rainwater in many areas around the world, including North Africa (Agarwal & Narain, 1997).

Devi (2005) mentioned most studies found that during the twentieth century the use of rainwater harvesting techniques declined around the world, partly due to the provision of large, centralized water supply schemes such as dam building projects, groundwater development and piped distribution systems. However, in the last few decades there has been an increasing interest in the use of harvested water with an estimated 100,000,000 people worldwide currently utilizing a rainwater system of some description (Heggen, 2000). As a result, rainwater harvesting has regained importance as a valuable alternative or supplementary water resource. Utilization of rainwater is now an option along with more ‘conventional’ water supply technologies, particularly in rural areas, but increasingly in urban areas as well.

2.1.3.1 Rain Water harvesting in developing world

a) Rain water harvesting in Africa

Unlike the developed world the use of RWH is mainly to supply potable water this is because centralized water supply projects including treatment facilities to areas with high population densities is often uneconomic for governments.

Although in some parts of Africa rapid expansion of rainwater catchment systems has occurred in recent years, progress has been slower than Southeast Asia. This is due in part to the lower rainfall and its seasonal nature, the smaller number and size of impervious roofs and the higher costs of constructing catchment systems in relation to typical household incomes.(UN, Habitat. htmal)

According to UN habitat, rainwater collection is becoming more widespread in Africa with projects currently in Botswana, Togo, Mali, Malawi, South Africa, Namibia, Zimbabwe, Mozambique, Sierra Leone and Tanzania among others. Kenya is leading the way.

UN habitat mentioned that, thousands of roof catchment and tank systems have been constructed at a number of primary schools, health clinics and government houses throughout Botswana by the town and district councils under the Ministry of Local Government, Land and Housing (MLGLH) (UN, habitat)

Rain water harvesting in Ethiopia is also a common practice for most of the households in Ethiopia to employ ‘informal’ rainwater harvesting by placing bowels, jerrycans, or any convenient materials at hand under eaves or even trees during rainfall. Despite the above fact, there is no readily available document, which can indicate the actual date as to when water harvesting has been started in Ethiopia.

However, some available physical evidences show that in Ethiopia ancient churches, monasteries and castles used to collect rain water from rooftops; and the history of rain water harvesting by the Axumite Kingdom dates back as early as 560 BC (habtamu, 1999). During this period, rainwater was harvested and stored in ponds for agriculture and drinking water supply purposes. This is confirmed from literature and visual observation on the remains of ponds that were once used for irrigation during that period (Ngigi, 2003). The documents also provide additional evidence for roof water harvesting set up in the remains of one of the oldest palaces in Axum. Other evidences include the remains of one of the old castles in Gondar, constructed in the 15-16 century which as a pond built for rainwater harvesting for drinking and religious rituals by the kings. Also during the rule of King Lalibela, ponds and underground water storage tanks were used both for drinking and religious rituals within the system of rock-hewn churches that have existed up to now (Ibid).

Though water harvesting, in its traditional form, has long been practiced in Ethiopia, promotion and application of rainwater harvesting techniques as alternative interventions to address water scarcity were started through government initiated (Ngigi,2003).

2.1.4 SWOT Analysis of Rain Water Harvesting

2.1.4.1 Strengths

a). Common Advantages

Simple construction: Construction of RWH systems is simple and local people can easily be trained to build these themselves. This reduces costs and encourages more participation, ownership and sustainability at community level.

Good Maintenance: Operation and maintenance of a household catchment system are controlled solely by the tank owner’s family. As such, this is a good alternative to poor maintenance and monitoring of a centralized piped water supply.

Relatively good water quality: Rainwater is better than other available or traditional sources (groundwater may be unusable due to fluoride, salinity or arsenic).

Low environmental impact: Rainwater is a renewable resource and no damage is done to the environment.

Convenience at household level: It provides water at the point of consumption.

Not affected by local geology or topography: Rainwater collection always provides an alternative wherever rain falls.

Flexibility and adaptability of systems to suit local circumstances and budgets, including the increased availability of low-cost tanks (e.g. made of Ferro cement, plastics or stone/bricks). (DTU, 2002)

b).Household level benefits

- **use of tank as a storage medium**: once the tank was empty of rainwater, some households used it to store water collected from conventional sources for later use, thereby freeing traditional water collection containers for re-use, and making economies by purchasing water in bulk.
- **Money saved purchasing water**: the amount saved, if any, was influenced by water fetching behavior before and after the tank. Savings accrued if DRWH water either partially or completely substituted for purchased water.
- **Money earned selling water**: in some communities (such as Kibengo in Uganda) the DRWH system represented an income earning opportunity through the sale of water to neighbors.
- **Improvements in the quality of life**: drudgery was reduced through the convenience and ease of collecting water in the home compound.
- I**mproved health and hygiene**: through having access to water which was safe for drinking and readily available for washing clothes and bathing more regularly. Family members were less exposed to water borne diseases present at traditional bathing spots.
- **Exposure to new technologies and new skills**: acquired by household members in tank use and maintenance (including roofs and gutters), in assessing water quality, and in recognizing the suitability of rainwater for potable uses.
- **Improved relations with neighbors**: through sharing water.
- **Improved household status**: due to the presence of the tank in the compound.

c). Community level benefits

- **opportunities for skills development and income generation**: amongst individuals such as masons, carpenters, technicians, casual laborers, and groups providing unskilled or semi-skilled labor for tank construction and maintenance, and materials' suppliers.
- **Improved access to water**: in several communities, tank owners were keen to share water with their neighbors, either for payment or as a gift for goodwill. If households with access to tank water significantly reduced the amount of water they collect from traditional sources, queuing times for others could be reduced.
- **Reduced costs of water**: if tank owners sell their water below the market rate, there would be downward pressure on the prices charged by conventional vendors. Whilst this would be beneficial for consumers it may be detrimental to the livelihoods of water vendors.
- **Improved access to information and advice about DRWH systems**: neighbors who wish to construct their own system have the opportunity to observe tank performance, durability and cost, and seek the firsthand experiences of tank owners.

Rees D.,(2000) also, mentioned the following advantages; Water harvesting gives very convenient supply of water as per requirement; it is largely independent of outside organization for construction and maintenance, and also gives fairly high water quality, which may be further increased by simple means. Water harvesting is a simple, cheap, and environmentally friendly technology. It minimizes some of the problems associated with potable water supply and environmental degradation (Leisa, 1998).

DTU (2002) also, suggested that collecting rainwater is not only water conserving, it is also energy conserving. Furthermore, rainwater is soft and can significantly reduce the quantity of detergents and soaps needed for cleaning as compared to typical municipal tap water. The introduction of more formal rainwater harvesting will normally be accompanied by the above mentioned advantages.

2.1.4.2 Weakness

High investment costs: The cost of rainwater catchment systems is almost fully incurred during initial construction. Costs can be reduced by simple construction and the use of local materials.

Usage and maintenance: Proper operation and regular maintenance is a very important factor that is often neglected. Regular inspection, cleaning, and occasional repairs are essential for the success of a system.

Water quality is vulnerable: Rainwater quality may be affected by air pollution, animal or bird droppings, insects, dirt and organic matter.

Supply is sensitive to droughts: Occurrence of long dry spells and droughts can cause water supply problems.

2.1.4.3 Opportunities

Mintesiont (2002) suggested that rainwater harvesting will have good opportunity when problems like ground water depletions, salinity or high cost of water treatment is an issue. If well designed, managed and promote, rainwater harvesting has user acceptance and users are committed to participate as well it is easy to mobilize communities. Its opportunity may also be seen when other water sources are at a distance.

2.1.4.4 Threats

a) Policy related threat

One of the main reasons for lack of support expressed in most National Water Policies towards DRWH is due to sectoral water development thinking. The old school theory of water development was unisectoral with least respect to other water sectors. With no competition for available water resources, this approach was sustained in the past. However, with increased socio economic development, demand for fresh water has increased. To supply to the demand, most countries have adopted Integrated Water Resources Management (IWRM) strategies, which considers "water resources management" rather than "water Management"(DTU, 2002).

DTU (2002) also mentioned that Due to single sector development approach in the past, professional outlook was limited to only surface and ground water development. This was highlighted as a policy constraint where the lack of trained and skilled persons in DRWH as a problem to promote the technology as a viable sources of water supply.

Simplicity and community orientation of DRWH technology has also been highlighted as another constraint in developing DRWH. According to Julius W., (2000) the western educated professionals find it difficult to understand the appropriate technologies like DRWH for rural poor, thus, it becomes difficult to promote such technologies at national level.

b) Institutional related threat

One on the fundamental factors for the success of any technology or a concept is its “ownership”. There should be an institution that takes the ownership to develop and foster the technology. While both surface and groundwater are owned by their respective institutional mechanisms, DRWH has no such owner. Kenyan and Ugandan policies have identified number of organizations at various levels responsible for water sector development and management. However, none of these organizations are responsible for development and promoting DRWH. Lack of quality standards and poor operation and maintenance, lack of allocation responsibilities and unclear definition of sector development roles are direct result of lack of an adequate institutional mechanisms for DRWH (DTU, 2002).

Inadequate professionals and lack of awareness on DRWH in many countries is a result of institutional weaknesses. Poor institutional structure is sited (Julius W. 2000) as one of the major causes threatening the sustainability of DRWH. It has been pointed out as a reason hindering the widespread development of DRWH.

However, the situation is expected to change with the current water sector reforms where development of water resources will be taken up as an integrated approach. It is expected that water in all its forms will be considered for development and management. With renewed interest in DRWH, it is expected that DRWH will be taken as a major source for development. Such development will essentially need institutional ownership if the technology and the concept are to be developed to serve as a means of household water security (DTU, 2000).

2.2. Methodological Review

2.2.1. The Process of Adoption of New Technologies

As one of the objectives of the present study is to identify the factors determining the adoption of improved DRWH technology, and since the studies on this aspect were found to be lacking in Ethiopia; a review of studies of technology adoption in the field of rain water harvesting for domestic uses, agricultural purposes and some other agricultural technology related socio economic characteristics of different countries has been presented below. This was found to be helpful in hypothesizing the variables of technology adoption in DRWH and in conceptualizing the models for in depth analysis of the hypothesized factors.

Historically, the original diffusion research was done as early as 1903 by the French sociologist Gabriel Tarde who plotted the original S-shaped diffusion curve (Rogers, 1962). According to Feder et al. (1985), adoption may be defined as the integration of an innovation into farmers' normal farming activities over an extended period of time. The authors classified adoption into individual adoption and aggregated adoption. They further made a distinction between models of individual adoption, which refer to static character of technology transfer, and models of aggregate adoption, which are dynamic and derive analytically the behavior of the diffusion process over time. The frequency distribution of adopters over time follows a bell-shaped curve and its cumulative frequency looks like the S-shaped curve (Rundquist F.M, 1984).

Mosher (1979) has also similar idea but he underlined the importance of information. He noted that because of fear of risks associated with the introduction of new technologies, at early stages, few adopters acquire full information. The same author also reported that the adoption pattern of a particular component is a function of profitability, riskiness, divisibility, or initial capital, complexity and availability.

According to Dasgupta (1989), the adoption process is conceptualized to include several mental stages through which an individual passes after first hearing about an innovation and finally deciding to adopt or reject it. The process generally includes five stages: awareness, interest, evaluation, trial and adoption. The time between the awareness of an innovation and its adoption is called adoption period and length of adoption period varies not only from individual to individual but also from practice to practice (feder et al., 1985; Dasgupta, 1989). They also noted that, households are categorized, according to their tendency to adopt as innovators, early adopters, followers and laggards.

The implication of S-shaped curve is that few individuals initially adopt new technologies. However, as time goes, an increasing number of adopters appear, in the end, the path of the diffusion curve slows and begins to level off attaining its peak. The implication is that because of fear of risks associated with introduction of new technologies, at early stages, few adopters obtain full information. The long run upper limit or ceiling on aggregate adoption is determined by the economic characteristics of the new technology and by the state of the economy (Griliches, 1980).

Diffusion ultimately determines the pace of economic growth and the rate of change of productivity rather than invention or innovation. Rosenberg (1972) noted "in the history of diffusion of many innovations, one can't help being stuck by two characteristics of diffusion process; its apparent overall slowness on the one hand, and the wide variations in the rates of acceptance of different inventions, on the other hand."

2.2.2 Models for Analyzing the Factors in Technology Adoption

The decision to adopt a technology or not is a binary decision. It can be represented as a qualitative variable whose range is actually limited. This variable is limited because it can only take on two values: 1 or 0 (adopt or not adopt). Aldric and Nelson (1984) noted that the regression model places no restrictions on the values that the independent (exogenous) variables take on, except that they not be exact linear combinations of each other. The author added that the dependent variable, however, i assumed to be continuous. But if Yi, the dependent variable, can take on only two values (say zero and one) the violation of this assumption is so egregious as to merit special attention.

Adoption decisions can be analyzed with binary choice models. The main assumptions underlying these models are: 1) the economic agent is faced with a choice between two alternatives e.g. adopt or not adopt a technology (DRWH in our case) and 2) the choice the agent makes will depend on his/her attributes or characteristics. The conceptual framework is to build a model which will allow us to predict how a particular economic agent with given attributes will decide. In other words, the objective of such a model is to determine the probability of a particular agent making one choice rather than the alternative (Pindyck and Rubinfield, 1981).

In most of the studies on adoption behavior the dependent variable is constrained to lie between 0 and 1 and the models used are exponential functions (Kebede et al., 1990). However, the decision to adopt a new technology is very effectively captured using binary choice models. Binary choice models are appropriated when the decision making choice between two alternatives depends on the characteristics of the problem. Three types of models have been proposed in the econometric literature for estimating binary choice models: the linear probability, logit, and probit models represented by linear probability function, logistic distribution function and normal distribution function, respectively. These functions are used to approximate the mathematical relationships between explanatory variables and the adoption decision that is always assigned qualitative response variables (Gujarati, 1995; Pindyck and Runbinfeld, 1981).

The major point that distinguishes these functions from the linear regression model is that the outcome variable in these functions is dichotomous (hosmer and Lemeshow, 1989). Besides, the difference between logistic and linear regression is reflected both in the choice of a parametric model and in the assumptions. Once this difference is accounted for, the methods employed in analysis using logistic regression follow the same general principles used in linear regression (Hosmer and Lemeshow, 1989).

Although Ordinary Least Squares (OLS) estimates can be computed for binary model, the error terms are likely to be heteroscedastic as it depends on the value taken by Xi, and leading to inefficient parameter estimates. Application of a linear probability model to this type of problem suffers from a number of deficiencies (Amemiya, 1981; Aldric and Nelson, 1984; Capps and Kramer, 1985; Gujarati, 1995), particularly, the one associated with the estimated probabilities in some cases being greater than one or lesser than zero. Though this defect can be corrected by defining F=1 if F(Xi' b) > 1 and F=0 if F(Xi B) < 0, the procedure produces unrealistic kinks at the truncation points (Amemiya, 1981).

These deficiencies could be avoided through the use of a monotonic transformation (probit or logit specification), which guarantees that predictions lie within the unit interval (Capps and Kramer, 1985). The fact that the models exhibit a cumulative distribution function enables to solve these problems. The use of probit and logit models, which give maximum likelihood estimates, overcome most of the problems associated with linear probability models and provide parameter estimators which are asymptotically consistent, efficient and Gaussian so that the analogue of the regression t-test can be applied.

The choice of a model with non-linear specification is dependent strictly upon the distribution of the disturbance term, u, and among these the normal and logistic are two of the most commonly assumed distributions, providing still another rationale for their importance (Aldric and Nelson, 1984). The authors added that the choice between the logistic and normal curves revolve around practical concerns such as the availability and flexibility of computer programs and personal preference and experience as they are so similar as to yield essentially identical results with an estimated choice probabilities that differ by less than .02. They further noted, probit and logit models employ normalization factors of 1 and 1.813, respectively giving an approximate factor ratio of 1.8 and an analysis applied to the same set of data using these models should produce coefficient estimates that differ approximately by a factor of proportionality, and that factor should be 1.8.

Amemiaya (1981) proposed a value of 1.6 to be approximate more closely and the most accurate value of the factor lies somewhere in the neighborhood of these two values. He further emphasized that care must be taken in choosing the appropriate model in cases like extremely large number of observations and with a heavy concentration of observation in the tails of the distribution where estimates from logit and probit may differ substantially. Thus in the univariate dichotomous model, it does not matter much whether one uses a probit model or logit model. In multi response or multivariate models, however, the probit and logit models differ from each other more substantially.

Available evidence shows that the logistic function is the most frequently used function in adoption studies. According to Hosmer and Lemeshow (1989), there are two primary reasons for choosing the logistic distributions: from mathematical point of view; it is an extremely flexible and easily used function; and it lends itself to a meaningful interpretation. Maddala (1983) and Shakya and Flinn (1985) have recommended probit models for functional forms with limited dependent variables that are continuous between 0 and 1, and logit models for discrete dependent variables.

2.3 Empirical Review

2.3.1 Empirical studies on technology adoption

The contribution of new technology to economic growth can only be realized when and if the new technology is widely diffused and used. According to Hall and Khan (2002), decisions to begin using the new technology are often the result of a comparison of the uncertain benefits.

According to Rogers and Shomaker (1971), adoption is defined as the decision making process in which an individual passes from first hearing about an innovation to final adoption. The decision of whether or not to adopt a new technology hinges upon a careful evaluation of a large number of technical, economical and social factors.

Yapa and Mayfield (1978) suggested that the adoption of an entrepreneurial innovate by an individual requires at least four conditions. These are (a) the availability of sufficient information (b) the existence of a favorable attitude towards the innovation (c) the possession of the economic means to acquire the innovation (d) the physical availability of the innovation.

2.3.2 Decision Behavior of households about Rain Water Harvesting

Degnet (1999) had summarized different empirical studies on the association between adoption decision and the factors which influence adoption particularly in less developed countries into the following groups.1) household characteristics such as age, education, gender, family size, experience and social status of the head of the family, 2) economic characteristics such as house ownership, availability of cash, 3) supply and institutional factors such as households access to credit, awareness creation and sensitization service, access to and availability of skilled labor and raw materials.

The success or failure of any rainwater harvesting technology will ultimately depend on the degree of acceptance by the households. It is essential that the needs and aspirations of the households are clearly understood and fully provided for in the planning, designing and implementation process. It should give sense in terms of productivity of resources used. (Martison et al.,2001).

Many researchers and experts in the field of natural resources conservation and rain water harvesting forwarded their reasons about different factors that affect the decision of household's to participate and efficiently use rainwater-harvesting works. As mentioned in CTA (2000) widespread adoption of rainwater harvesting techniques by the local population depends on cost and simplicity of the technology for implementation and maintenance. Another consideration would be whether success in rainwater harvesting promotion and adoption is facilitated by integrating different forms of rainwater harvesting systems.

Adoption of rainwater harvesting technologies despite their technical benefits will depend on knowledge of socio-economic and cultural dynamics, on the part of the technology developer, and on the household/ community perceptions. A comparison of promotion approaches of the same technology in different environments, either by the same or different actors, reveals the importance of participatory, household friendly approaches, and due consideration of socio-economic and cultural backgrounds (Ngiggi,2003).

Abdulkarim (2002) enumerated conditions that should be considered during rain water harvesting system planning and design for the technology to be more acceptable by the users. These are a) Socio-economic aspects which may include community acceptance and participation, Understanding of needs and aspirations, prioritization of needs, appropriate technology, proper planning and analysis, pilot scheme approach, technical services, cost and benefit consideration of investment and operation, application,.

FAO (1995) stated similar criteria to be considered while selecting rainwater harvesting techniques. To mention, firstly, before selecting a specific technique due consideration must be given to the social and cultural aspects prevailing in the area of concern as they are important and will affect success or failure of the project. Second, it is becoming more widely accepted that unless people are actively involved in development projects, which are aimed to help them, the projects are doomed to fail. Thus, it is important that the beneficiaries participate in every stages of the project.

As a concluding remark, it is essential to mention and summarize focusing on very influential factors that determine households' willingness to participate in water harvesting practices. Hence, the following points were commonly cited in many literatures, as determinates of households' decision to participate in rainwater harvesting activities.

Awareness and sensitization: surprising deposited the fact that rainwater harvesting have been around for hundreds of years. It has never been sufficient attention as viable solutions to our food and environmental problems. If it had been given sufficient attention, like other technologies, with the accompanying services, equipment and personnel, the situation would have been radically different (Critchley, 1991; FAO,1994).

Legal, policy and institutional issues: despite the centrality and potential of rainwater harvesting in alleviating water scarcities, it is surprising to find no comprehensive policy guiding it in the Greater Horn of Africa countries (Ngiggi, 2003).

Environmental issues: in general rainwater harvesting systems are environmental friendly, rainwater harvesting technologies have been reported to reduce soil erosion by capturing roof water and hence reduce run offs and land degradation (Hatibu and Mahoo, 2000).

Awareness creation by Water sector service; Making use of the available service within government departments and equipping them with the necessary skills and material support would enhance adoption and replication. Households' exposure visits and stakeholders' collaboration and networking would suffice in disseminating the technologies (Ngiggi 2003).

Public perception and acceptability: One of the key factors in the success or otherwise of any water reuse scheme is the perception of the users and the acceptability to them of the existing or proposed technology. It is important that the social and cultural aspects of water use are considered when planning and designing such systems (Jeffrey & Gearey, 2006). The same author states also, past failure to adequately take into account and address public concerns has led to the cancellation of a number of potentially beneficial reuse schemes.

Satisfaction with present water sources: If households have no problem in terms of accessibility and convenience of water supply, cost and quality of water. There may be a tendency to overlook the need to adopt DRWH practices.

Limited previous exposure to permanent DRWH systems: lack of familiarity with DRWH systems within the community hinders the adoption and effective use of the technology.

Shortage of skilled masons to construct water retaining structures: specialist training is usually required to develop the community's skills base in the new technology.

Lack of responsibility for self help: in some countries, there is the widespread expectation that water provision is the government's responsibility (Uganda and Sri Lanka). Consequently many communities are unwilling or not motivated to address their water supply problems alone, particularly if it may compromise their subsequent involvement in piped water supply projects (for example, Kampala).

Socio economic factors

These factors include households' income, size, level of education, occupation and others demographic characteristics. Therefore, those factors are used to assess the level of adoption and use of DRWH. Hence, a consideration of socio-economic factors is very important.

Household surveys often gather a large amount of information on household socioeconomic and demographic characteristics such as size and composition (by sex and age) of the household, education level and occupation of each member, and earnings, as well as data on household living conditions such as number of both rooms, toilet rooms, availability of laundry machine, car etc.).

Household water consumption is also partly influenced by the level of education of household members (mainly household heads). It is believed that education is directly related to household per capita water consumption. The reason is that as the level of education of household heads increases; there would be more awareness of the health benefits of water and frequent bathing and washing in the household.

Household's Perception on Quality of Water Service

Because water quality and reliability may vary from one source to another, such variables should be included in household willingness to adopt other alternative sources choice. These include quality opinion variables about the taste, smell, and color of the water and hours of water availability and potential pressure problems. These data are typically provided by households themselves and may be subject to misreporting. Variables measuring household opinion or perception about water quality should also be used with caution, because they may introduce endogeneity into the model. For example, households that suffered from water-related diseases in the past may be more inclined than other, healthy households to believe that water is unsafe and may therefore exhibit different behavior regarding water use (Gould and Nissen-Peterson (1999). Also, quality perceptions may be correlated with income and education, implying collinearity issues. To avoid such biases, one could develop an average of opinion (on water quality) for households living in the same neighborhood, or relying on the same water source, if the average could be computed without considering the opinion of the individual household under consideration.

Rainwater quality and health: Some other literature states rainwater is often used for drinking and cooking and so it is vital that the highest possible standards are met. Rainwater, unfortunately, often does not meet the World Health Organization (WHO) water quality guidelines. This does not mean that the water is unsafe to drink. Gould and Nissen-Peterson (1999), in their recent book, point out that the Australian government have given the all clear for the consumption of rainwater 'provided the rainwater is clear, has little taste or smell, and is from a well-maintained system'. It has been found that a favorable user perception of rainwater quality (not necessarily perfect water quality) makes an enormous difference to the acceptance of RWH as a water supply option. There are several simple methods of treatment[2] for water before drinking.

[2]
- Boiling water will kill any harmful bacteria which may be present
- Adding chlorine in the right quantity (35ml of sodium hypochlorite per 1000 litres of water) will disinfect the water
- Slow sand filtration will remove any harmful organisms when carried out properly
- A recently developed technique called SODIS (Solar Disinfection) utilizes plastic bottles which are filled with water and placed in the sun for one full day.

3. MATERIALS AND METHODS

3.1 Description of the study area

Mekelle city is one of the ancient cities of Ethiopia although there is no well known written document that narrates about its foundations. Its historical back ground is then based on oral sayings. Thus, mekelle city was established in the 14th century by the reigm of Atse Wadm Reheod and later, expanded by Atse seife Raed and Atse Zerayakob. However, it was in1864, flourished into modern town when Atse Yohanse 4th chooses Mekelle as a center of his administration.

Today, mekelle city is one of the fast growing cities of Ethiopia. The total area of the city is 19,200km^2. And it is located in the north part of Ethiopia some 783km far from Addis Ababa. The city is the center of many federal, regional and international organizations. According to the regional bureau plan and finance population projection, the projected population estimate based on the population census of 2007, is a total population of 272,519 out of which 132,474 (48.6% male) and 140,045 (51.4% female) and average population growth of the city is 4.7%. This rapid population growth is attributable to a combination of factors including continued migrations from the rural country sides and natural growth (BoFED, 2011).

3.1.1 Location and Climate

Geographically it is located between altitudes of 2000 - 2200 m.a.s.l and has a weina-dega agro-ecology zone (medium high land climatic condition). The city is found in 39`28 east & 13`28 north with rainy and dry seasons as the two important seasons of the city and its average annual rainfall is 618.3mm/year, this rainy season is characterized as erratic, unreliable and unevenly distributed throughout the year. And has an average mean temperature of 19`c. (WRDF, 2008).

3.1.2 Demography

The population of Mekelle city has been growing considerably in the last 10 years. The city water supply service has attempted to cover the growing water demand. However, so far it has only achieved limited results. Reasons for water shortage of the city includes expansion of construction and industrial activities, increase in city's population due to both natural growth and immigration from surrounding areas in search of better living conditions. (MWSSO, 2012).

In order to distribute the available scarce water equitably among the population of the city, the enterprise has introduced a shifting system since four years ago. According to the enterprise, the long term solution to the city's water supply problem lies in tapping the surface water potential by constructing a dam. In this regard, all the required studies have been at the verge of completion and construction work is planned to begin in 2 years time. Even if all things go as planned, the water from supposed dam will not be available until 2018 including the construction work that will take at least 5 years to be completed. However, the current water supply situation of the city is so acute that it renders impossible waiting for such a long time. (Ibid)

Table 3.1 population projection of the study area

Year	**2004**	**2007**	**2010**	**2015**	**2020**	**2025**
Population	207,308	237,456	272,223	337,686	413,420	505,422
Annual G. rate	4.63	4.66	4.45	4.4	4.13	3.95

Source: Appraisal report of MWSSO expansion project, 2008

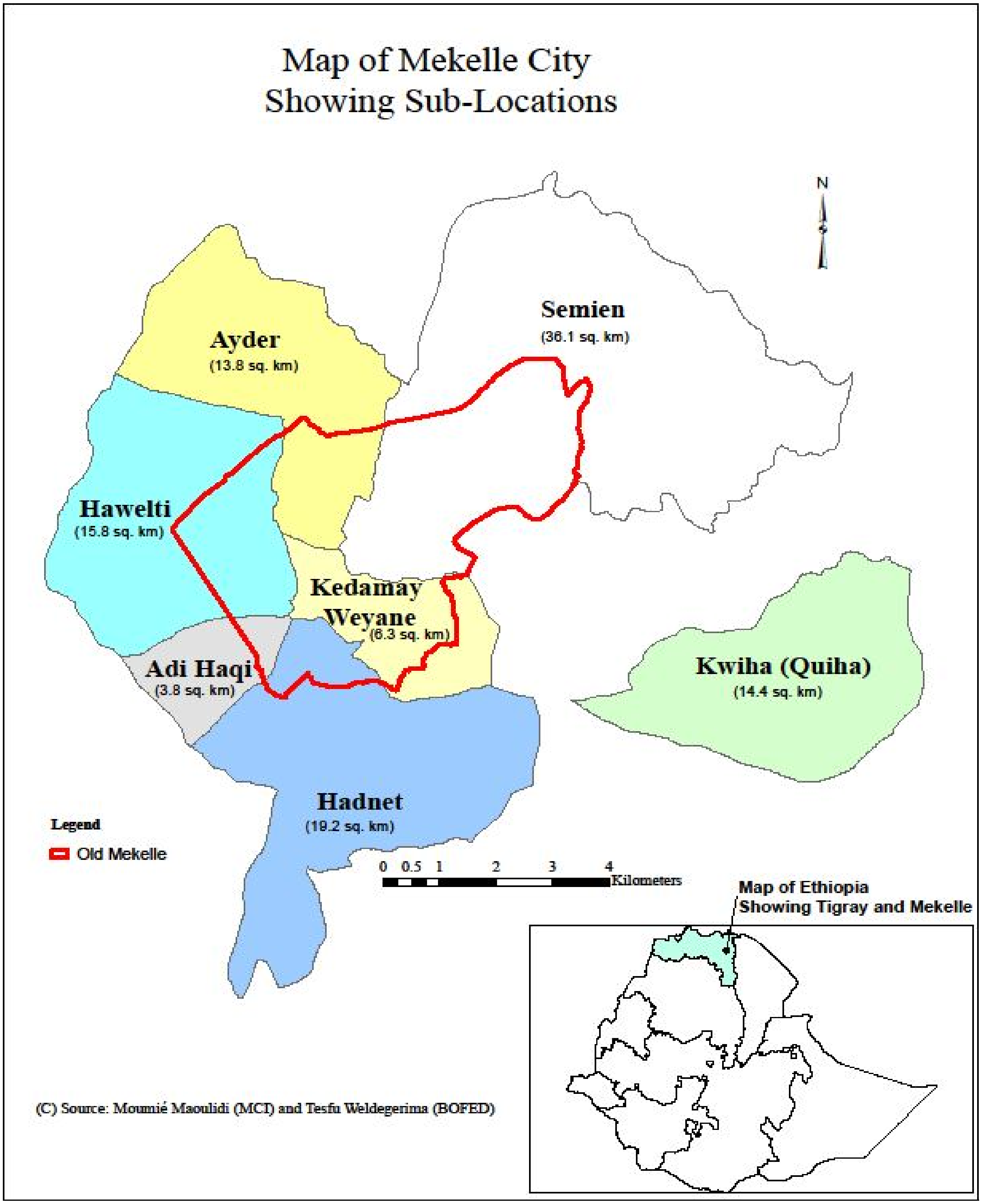
Table 3.2: Population distribution by kefle ketma[3]

S. No	Kifle ketma	Population		
		2002	2003	2004
1	Kedemay Weyane	44,409	46,497	48,682
2	Hawelti	20,292	21,245	22,244
3	Hadnet	45,606	47,750	49,994
4	Adihaki	25,587	26,790	28,049
5	Ayder	31,472	32,952	34,500
6	Semen	62,802	65,754	68,844
7	Quiha	18,397	19,262	20,167
	Total	248,566	260,249	272,480

Source: BoFED ,2011

[3] Kefle ketma is local word of the study area to mean that administration unit.

Fig 3.1 Map of the study area



Adopted from BoFED Mekelle city profile, 2011

3.2 Water supply situation and demand in Mekelle

In this part the existing water supply source, distribution and demand situation of the study area were discussed.

3.2.1 The Existing Water Supply Source and Production capacity

As to the information obtained from Mekelle Water Supply Service Office, the introduction of a modern water supply system in Mekelle town began by 1950 ec and in the last 50 years only small changes has been made on the water service production and distribution system. The main water source for mekelle water supply is from 22 boreholes with depth ranging from 65 m to 250 m. out of these, 11 are located at tabia aynalem, 6 boreholes are in Quiha and 1 borehole each in Sewhi Neguss, felegdaero and in Lachi 2 boreholes in chenfers. Water production is effected by submersible pumps. The water that is produced from these boreholes is located in to the town's reservoirs, and then after disinfection process the water is delivered to the distribution networks (WRDF, 2008).

The supply capacity of the existing water sources is deteriorating from time to time and some boreholes are abandoned due to the increase in demand and consequent shortage of water and over depletion (Ibid). The production and distribution capacity of Mekelle water supply in 2012 is 20,500 M^3/day including about 20% of non revenue water (system leakage) while daily average demand for water of the city is estimated to be 43,992m^3. That means, the water supply of the city covered only around 50% with 40 liters per capita domestic consumption. Water services are provided to about 272, 539 people in the city through 23,000 connections and about 32 public stand posts. This service is provided to residential and non residential uses out of the total service connections, about 87% are residential, using about 52.7% of water supplied; 13% are governmental, commercial and business, which uses 47.3% of the remaining water supplied. (MWSSO, 2012).

3.2.2 Existing water supply facility

3.2.2.1 Storage facility

The water supply system of Mekelle currently has four storage facilities

- A 2000 m^3 storage capacity reservoir at enda-Gebriel, at the head of most of the city's water distribution system and controlling the city's water supply to zone two.
- A 500 m^3 storage capacity reservoir not far from the 2000 m3 storage capacity reservoir which controls the city's water supply for zone one.
- A 2000 m^3 storage capacity reservoir at the water supply service premises which is within the city's water distribution system which controlling the city's water supply to zone three.
- A 350 m^3 storage capacity reservoir located at the eastern hill side, obtaining water from a dedicated well in Aynalem well field and controlling the city's water supply to zone four.

3.2.2.2 Treatment facilities

- Mekelle water supply service office has not any treatment plant. So that chlorination takes place manually at each reservoir before the water is distributed to the transmission lines.

3.2.2.3 Transmission mains

- The water supply system of Mekelle has more than 330 Km of water supply pipelines with size ranging from 25 to 600 mm in which some are laid before 55 years and some are before 7 years as extension of the new development areas. Most of the pipes in the network system are very old and need replacement. Furthermore, the distribution system of the town is not also organized to identify by layout, size, depth and age. Due to improper network lay outs it is difficult to undertake timely maintenance, replace and control leakage which account up to 20% loss

3.2.3 Water Demand and Consumption

Due to water shortages, consumption of water in the city is below actual demand therefore, consumption is driven by the amount supplied rather than the actual demand. And the current situation can be summarized as

- The service level of the water supply system in mekelle city comprise house and yard connections and public taps
- People with in-house services use on average 41.6 liter per household per day,
- Water service is provided to residential and non residential uses out of the total service connections, about 87% are residential, and 13% are non residential customers.

There are different types of water supply customers in the study area

- Domestic customer - House connection, which enable the customers to use water solely for domestic purpose.
- Commercial customers - Those have connection for restaurants, grocery, cafe, bar, car washing, etc.
- Governmental customers - Those use water for offices, colleges (Universities), health centers, school, etc.
- Industrial customers - This group use for process of production.

Table 3.3 Customer types and their average daily water consumption.

Types of customers	Water supply		Daily consumption in m^3	
	Number	%	Average consumption	%
Private customers	28,050	86.1	10,838.26	52.6
Non household customers	4,550	14	9,738.13	47.4
Total	32,595	100	20,576.39	100

Source: MWSSO,2012 annual report

3.3 Method of Data Collection and analysis

3.3.1 Data sources and data collection procedure

3.3.1.1 Data sources

Both primary and secondary data sources are used for this study. The primary data is collected using structured questionnaire. The data on socio-economic aspects of the households such as age of a household head, education level, residential plot size, family size, and other economic, institutional and technological factors which explain household's decision behavior regarding domestic roof water harvesting participation.

The secondary data is collected from relevant sources such as the water supply service office of Mekelle, city Municipality and other related offices and officials. The data are collected from reports, statistical document as well as published and unpublished documents.

3.3.1.2 Sampling procedure and Sample size

According to Mekelle city administration classification, the city is classified in to seven administration units (kefele ketmas); the sample for the study is draw from two sub cities, and the selection of the two sub cities is using purposive sampling method aiming to ensure representativeness of adopters and non adopters of DRWH as well as all residence types. Thus, based on the categories of settlement that consist all types of residence and the presence of both adopters and non adopters of DRWH practices, Hadenet and Adihaki having total population of 49,994 and 28,049 respectively are selected as Enumeration areas (EA). After selecting the area, the total community living in those kefele[4] ketma (sub cities) was stratified using stratified sampling method in to four groups (strata) based on their house ownership type. As a result, the

- [4] Kefle ketma, Hadent, Adi Haki, are to mean specific administration units
- Nebar tehzto, Mahber, lease and condominium are to mean types of house ownership registration of individual respondents.
- Ketena= specific local administration unit

main stratification unit was their house ownership registration. Then, the types of house were classified as follow. Group 1 includes residences having Nebar Tehzeto registration type (old settlements), group 2 includes residences having condominium registration type , group 3 includes residences having Lease registration type and group 4 includes residences having Mahber (association) registration type. In view of this 30 sample households were selected using purposive sampling technique from each stratum or survey domain, This was done by considering the financial constraints, time shortages, lack of transportation and the presence of similar socio economic characteristics of the population groups (presence of homogenous characteristics) in the study area. Thus, a total of two Enumeration areas (EA) and four enumeration categories (EC) out of which a total of 120 households were included in the model as sample respondents. In addition to that, 20 non household respondents (such as government institutions, industries and commercial houses) were also included in the study using purposive sampling and analyze using focus group discussion. The total sample respondent institutions were equally taken from four different institutions five from each group. Thus, a total of 140 respondents were included in the study.

Prior to the final administration of the questionnaires several steps were passed through. First, enumerators had given training and briefings on the objectives and contents of the questionnaire and have been also acquainted with the basic techniques of socio-economic data gathering and interviewing techniques. Secondly, the questionnaires were tested at the household level on 15 purposively selected households. Thirdly, some amendments on the questionnaire were made following the results of the pretest.

3.3.2 Methods of data analysis

Both descriptive statistics and econometric models are employed to study the relationship between the dependent and independent variables. Using descriptive statistics the mean, standard deviation, minimum as well as maximum values of variables were indicated. The result obtained is used as an indicator of the relationship between dependent and independent variables. Econometric model is used to study relationship between variables empirically. Thus, the binary logit model (logistic regression function) is used to analyze factors affecting household decision to adopt domestic roof water harvesting practices.

3.3.2.1 Binary logistic model

In participation decision studies, responses to a question such as whether households' are deciding to participate in a given technology could be 'yes' or 'no' a typical case of dichotomous variable. A variety of statistical models can be used to establish a relationship between the household characteristics and the decision for participation. The inadequacy of the linear probability model suggests that a non-linear specification may be more appropriate and the candidate for this is an S-shaped curve bounded in the interval of 0 and 1 (Amemiya, 1981; Maddala, 1983). These authors suggested the S-shaped curves satisfying the probability model as those represented by the cumulative logistic function (logit) and cumulative normal distribution function (probit).

Hosmer and Lemshew (1989) pointed out that a logistic regression has got advantage over other model in the analysis of dichotomous outcome variables. There are two primary reasons for choosing the logistic distribution. These are 1) from a mechanical point of view, it is an extremely flexible and easily used function, and 2) it lends itself to a meaningful interpretation. The logit model is simpler in estimation than the probit model. Therefore, a binary logistic regression model is going to use to study the decision behavior of sample households (Pindyck and Rubinfeld, 1981).

Following Hosmer and Lemshew (1989), the logistic distribution function for identification of the adopter and non adopter households can be defined as:

$$Pi= \frac{1}{1+e^{-zi}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 1$$

Where P_i is the probability of the i^{th} households being adopters of DRWH and Z_i is a function of m explanatory variable (X_i), and expressed as:

$$Zi = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \text{----} + \beta_m X_m \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 2$$

Where B_o is the intercept and $B_{i\,(1,2\ldots m)}$ are slope parameters in the model. The slope tells how the log-odds in favor of being adopter of domestic roof water harvesting practices change as independent variables changes.

Since the conditional distribution of the outcome variable follows a binomial distribution with a probability given by the conditional mean Pi, interpretation of the coefficient is understandable if the logistic model can be rewritten in terms of the odds and log of the odds (Gujarati, 1995). The odds to be used can be defined as the ratio of the probability that a household is adopter (P_i) to the probability that the household is not adopter (1- P_i). But

$$1-P_i = \frac{1}{1+e^{zi}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 3$$

Therefore,

$$\frac{P_i}{1-p_1} = \frac{1+e^{zi}}{1+e^{-zi}} = e^{zi} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 4$$

And

$$\frac{p_i}{1-p} = \frac{1+e^{\ zi}}{1+e^{-z}} = e^{\beta o +} \sum_{i=j}^{m} \mathrm{Bixi} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots .5$$

Hence, the above econometric model is used in this part of the study to identify variables that affect willingness to adopt domestic roof water harvesting practices.

Before running the model, it would be necessary to check whether there is multicollinearity among the candidate variables and verify the degree of association among discrete variables. The reason is that the existence of multicollinearity will affect seriously the parameter estimates. If multicollicnearity turns out to be significant, the simultaneous presence of the two variables reinforces the individual effect of the variables. However, omitting significantly interacting terms incorrectly will lead to a specification bias. To this end, the coefficients of the interaction of the variables indicate whether or not one of the two associated variables should be eliminated from the analysis.

According to Gujarati (1995), there are various indicators of multicollinerity and no single diagnostic will give us a complete handle over the collineraity problem. Of various indicators of multicollinerity, the variance inflation factor (VIF) is used in this study to check whether there is multicollinerity or not among the continuous explanatory variables. Where each continuous explanatory variable is regressed on all the other continuous explanatory variables and coefficients of determination for each auxiliary or subsidiary regression were computed. Moreover, Gujarati (1995), stated that a high R^2 obtained could only be a surface indicator of multicollineraity. Therefore, a measure of multicollineraity associated with the variance inflation factors is defined as:

$$\mathbf{VIF}(\boldsymbol{Xj}) = \frac{\mathbf{1}}{\mathbf{1}-\boldsymbol{R}^{\mathbf{2}}}$$

Where R^2 is the coefficient of determination where the variable X_j is regressed on the other explanatory variables. A VIF value greater than 10 is used as a signal for a strong multicollineraity (Gujarati, 1995).

Likewise, there may also be interaction between two qualitative variables, which can lead to the problem of multicollinearity or association. To detect this problem, coefficients of contingency were computed from the survey data. The contingency are computed as follows.

$$C = \sqrt{\frac{x^2}{N+x^2}}$$

Where:

C= coefficients of contingency,

X^2= Chi-square random variable, and

N= total sample size.

The parameters of the model were estimated using the iterative maximum likelihood estimation procedure. This yields unbiased and asymptotically efficient and consistent parameter estimates.

In reality, the significant explanatory variables do not all have the same level of impact on the decision of households. The relatively important explanatory variables in decision can be measured by examining variable elasticity defined as the percentage change in probabilities that would result from a percentage change in the value of these variables. To compute the elasticity, one needs to select a variable of interest, compute the associated p_i, vary the X_m of interest by some small amount and recomputed the p_i, and then measure the rate of change as dp_i / dx_i, where dx_i and dp_i

stand for percentage changes in x_i and p_i respectively. When dx_i is very small, this rate of change is simply the derivative of p_i with respect to x_m and it is expressed as follows (Aldrich and Nelson, 1984).

$$\frac{dpi}{dxi} = \frac{exp(zi)}{1 + \exp(z!)} * \frac{1}{1 + \exp(zi)} \hat{ß} = p(1 - p)\hat{ß}$$

The impact of each significant explanatory variable on the probability of willingness is calculated by keeping the continuous variables at their mean values and the dummy variables at their most frequent values.

3.4 Definition of Variables and Working Hypothesis

This study focuses on identifying socioeconomic, technological, attitudinal and other factors that affects households' decision to adopt DRWH practices in mekelle. In the attempt to understand and to answer the main research objective, this study has the following variable definition and working hypothesis. Once the analytical procedures and their requirements are known, it is necessary to identify and describe the potential explanatory variables. Therefore, this part is treated as follow.

3.4.1 Participation decision study

In this part, identifying and defining dependent and independent variables for the participation decision study was done based on theoretical and empirical findings.

3.4.1.1 The dependent variable of the model

The dependent variable for the binary logistic analysis has dichotomous nature representing the practical status of the household to adopt DRWH practices. The variable takes the value 1 if the household is adopting DRWH[5] and 0 otherwise.

[5] In the context of this study, a respondent is said to be adopter if he/she is formally harvesting rain water for domestic uses having above or underground tank.

3.4.1.2 The independent variables of the model and hypothesis

The independent variables of the participation decision study are those which are expected to have association with the adoption decision behavior of the households in rain water harvesting practices. Different researchers come up with different results as to what factors can influence households decision to adopt or to have rain water harvesting structures. Some mention the socio economic factors as the leading.

a). Demographic factors

Age of the respondent (**REAGE)**: This is a continuous variable in which older household heads are reluctant for new technologies. They tend to be security conscious to take risk of adopting an innovation and their less quantity demand for water than young people. On the other hand, young household heads are often expected to take risk due to their long planning horizon and high demand for water than elders. Therefore, adopters are relatively younger and middle-aged households (Dasgupta, 1989). (DTU, 2002) has reported that household headed by elderly people in Ethiopia and Srilanka have no interest to participate in rain water harvesting. (Bekelle and Holden et al 1998) also reported similar negative relationship between age and adoption of land conservation practices in the high lands of Ethiopia. However, in this study, it is hypothesized that increased age would have a negative impact on the participation decision in water harvesting practices.

Respondent's Marital Status (REMS): This is a dummy variable taking 1 if the respondent is married; 0 otherwise. This variable is expected to have a positive sign since married people are more cautious of the health and other risk involved in poor water supply service due to family responsibility in the future than the single ones.

Respondent's family size (REFS): There are two different views concerning the impact of family size on decision to adopt RWH. One study has shown that as the number of family size increases, the demand for water also increases hence households decide to adopt RWH also increase. On the other case, a household with low level of income increase in family size will also increase household's expenditure so that a household is unwilling to invest in such supplementary source of water supply. Thus a negative relationship is expected in the second case.

b). Social factors

The education level of the respondent (REEDU): It is expected that households with higher educational level are more aware of the different benefits that could be gained from the use of rain water harvesting. According to (Dasgupta, 1989), adopters tend to have higher level of formal education because educated people are more open to accept new innovations and technology interventions than illiterate once, thus education level is hypothesize to influence decision of households for participation positively and a dummy variable 1 is specified for formal education (primary, secondary and tertiary) and 0 otherwise.

Respondent's perception to quality of the existing supply (**REPQWS)**: Without any theoretical a priori, if households perceive a good quality then there will be no incentive for them to prefer adoption of RWH technology and vice versa. A dummy variable 1 will be specified for households who perceive high quality and zero otherwise. If the household/respondent considers the existing water supply in the town is high quality, we expect a negative relation between this variable and adoption of RWH practice.

Respondent's perception to the reliability of the existing water supply (**REPRWS)**: It is hypothesized without any theoretical a priori, if households perceive that there is adequate water supply then there will be no incentive for them to participate in harvesting roof water and vice versa. A dummy variable 1 will be specified for households who perceive adequate supply and zero otherwise. If the household/respondent considers the existing water supply in the town is reliable, we expect a negative relation between this variable and adoption of RWH practice.

Households participation in social responsibilities (RESRESP): The membership of household heads in local organizations (like edir, equb, marketing cooperative, saving and credit cooperative, community police etc) and associations (like women, and youth associations) are expected to have a positive influence on household' decision to invest on RWH technology. Different literatures suggest that technology dissemination uses local organizations and associations as ways of reaching the whole community. Therefore, being a member of any local organization and/or association could make the household learn and be easily convinced, by another beneficiary household, who is a member in same organization or association and has adopted the technology intervention.

c). Economic factors

Monthly income of the household (**REMIN)**: This continuous variable is a sum of the head's income and the income of other members of the family. Different literature suggests that there is a positive relationship between income and household's decision to invest on rain water harvesting technology. Theory also supports this perception that income and quantity demanded are positively related in the case of normal goods. As a result a positive sign is expected on the variables of income.

Ownership of the house (OWNHOUSE): any investment decision on residences is directly related with ownership of the house. Ownership of the house may affect household decision to adopt new technology. Therefore, households who are living in rent house may not have the motivation to adopt the technology. On the other hand, households having their own house have incentive to adopt the technology. Thus, ownership of the house is expected to have positive impact on the willingness of household's to adopt RWH technology.

d). Attitudinal factors

Attitude towards the importance of DRWH (ATTIDRWH): Another measure of the attitude of a given respondent to adopt a technology is his perception about the importance of RWH technology. The existence of a favorable attitude towards new water harvesting technologies facilitates adoption. FAO (1994) considered technological appropriateness as a key determinant factor for the adoption and promotion of water harvesting practices across potential users. (Bekelle and Holden, 1998) found positive relationship between attitude towards new land conservation technologies and adoption by users. Sometimes, rain water harvesting technologies are blamed to be beyond users know- how and ability to construct, maintain and manage the system. The users will not easily adopt any technology that is too complex. Therefore, user’s attitude towards the uses and convenience of rain water harvesting technology is expected to be related positively to the decision of households to accept the technology.

E). Technological factors

Affordability of DRWH technology (ARWHT); Different literature suggests that low income households have a negative relationship between tank size and investment cost of DRWH technology. As the low income household needs to increase the size of the tank in order to collect more rain water its cost of investment also increase. Theory also supports this perception that “as price rise quantity demanded decrease”. As a result a negative sign is expected on the variables of affordability of investment cost.

4. RESULTS AND DISCUSSIONS

This part is mainly concerned with the description and interpretation of the findings. Thus, some of the socio-economic, attitudinal and technological characteristics are discussed below. And the analysis was made to identify the most important factors that affect the adoption of DRWH and to measure the relative importance of the different variables on adoption of DRWH.

4.1 Results of descriptive statistics

4.1.1 Household characteristics

Table 4.1. Demographic characteristics of sample respondents by household group

Category	Adopters		Non adopters		Total		Chi-square
	Freq	%	Freq	%	Freq	%	
Sex of respondents							
Male	23	74.20	79	88.76	102	85.00	3.83*
Female	8	25.80	10	11.34	18	15.00	
Marital status							
Married	24	77.42	72	80.90	96	80.00	8.68**
Single	1	3.22	13	14.61	14	11.67	
Divorced	6	19.35	4	4.49	10	8.33	
Educational status							
Illiterate	2	6.45	18	20.22	20	16.67	3.81
Primary School	9	29.03	19	21.35	28	23.33	
Secondary School	6	19.35	20	22.47	26	21.67	
Diploma & above	14	45.16	32	35.96	46	38.33	

Source: survey result

The minimum and maximum ages registered were 31 and 67 years respectively, with a standard deviation of 7.73 years. The average age of the sample households was 50.5 years and the average age figure is 48.5 and 51.2 for adopters and non adopters respectively. This shows young people have more probability to adopt new technology (Table 4.2).

Table 4.2. Household characteristics of sample respondents by household group

Attributes		**Obs**	**Mean**	**Std. Dev.**	**Min**	**Max**	**t-test**
Age	Adopters	31	48.48387	6.587215	37	60	1.699*
	Non adopters	89	51.20225	8.010192	31	67	
Family size	Adopters	31	5.225806	1.627066	3	9	-3.089***
	Non adopters	89	4.202247	1.575233	1	9	

Source: survey result *, **, *** Significant at 10%, 5%, 1% level of significant respectively.

4.1.2 Economic characteristics

With respect to monthly income of the sample household, it was calculated by comparing the monthly income reported by the respondent with that of the monthly expenditure plus a 5 percent estimated saving of that respondent. In this regard, the monthly income of the respondents ranges from 2000 birr to 9,500 birr. The average income is 4,543.333 birr with a standard deviation of 1,741.087 birr. The survey result indicates that adopters have average income of 6,367.742 birr. The corresponding figure for non adopters was 4,676.404 birr. About 39.17 percent of the sample respondents have other source of income other than the income of the household head from employed family member or house rent. The figure will be 22.50 and 16.67 percent for adopters and non adopters respectively. (Table 4. 3)

Table 4.3. Economic characteristics of household by household group

Attributes		Obs	Mean	Std. Dev.	Min	Max	t-test
Monthly Income	adopters	31	6367.742	1473.632	4000	9500	-5.84***
	Non adopters	89	4676.404	1358.31	2000	8000	
Plot size	adopters	31	302.5806	99.34679	175	500	4.49***
	Non adopters	89	188.1798	129.0353	41	500	
Monthly expenditure	adopters	31	5851.613	1484.334	3200	9000	5.07***
	Non adopters	89	4391.573	1345.41	1800	7600	

Source: survey result

All house ownership registration types were included with their different plot sizes (such as Nebar tehzto, Condominium, Lease and Mahber) (table 4.4). Accordingly, the survey result indicates the respondents residential plot size ranges from 41 sqm to 500 sqm. The average residential plot of adopters is 302.58 sqm with a standard deviation of 99.3468 sqm. The corresponding figure for the non adopters is 188.18 sqm with standard deviation of 129.0353 sqm. This result indicates that large plot size encourages household's decision to adopt DRWH practices. (Table 4.3)

Table 4.4. Respondent's house registration type

Attributes	adopters		Non adopters		Total		Chi-square
	Freq	%	Freq	%	Freq	%	
Nebar Tehzto	11	35.48	19	21.35	30	25.00	26.57***
Condominium	0	0	30	33.71	30	25.00	
Lease	16	51.61	14	15.73	30	25.00	
Mahber	4	12.90	26	29.21	30	25.00	

Source: survey result

Of the total sample household heads 15.8 percent have some responsibility at their kebelle (ketena). The figure was 29 percent and 11.2 percent for the adopters and non adopters respectively. The higher figure for the adopters when compared with the non adopters may indicate that as the household head assume some responsibility, the chance of getting information and hence understanding about the advantages of DRWH increase. Thus contributes to decide to construct some form of rain water harvesting tank.

The situation in the perception of water supply reliability and quality shows, 74.2 and 25.8 percent of the non adopters reported that there is unreliable and reliable water supply respectively in the study area. The corresponding figure for the adopters is 67.7 and 32.3 percent respectively. With respect to the quality of pipe water supply, the adopters reported that 19.35 and 80.65 percent were satisfactory and poor quality respectively. The corresponding figure for the non adopters is 65.17 and 34.83 percent were reported satisfactory and poor quality respectively. Thus, the existing water supply reliability and quality contributes to decide to adopt DRWH practices.

Table 4.5. The importance of adopting DRWH

Attributes	adopters		Non adopters		Total		Chi-square
	Freq	%	Freq	%	Freq	%	
Important	27	87	30	33.71	57	47.5	26.28***
Less Important	4	13	59	66.29	63	52.5	
Not important	0	0	0	0	0	0	

Source: survey result

From the existing water supply problem point of view the number of adopters are few in number. Out of the total 120 sample respondents, a total of 31 households were reported as adopters. With regard to the importance of adopting DRWH, 87 and 13 percent of the adopters reported that important and less important respectively. The corresponding figure for the non adopters is 34 and 66 percent respectively. But no household is reported that DRWH is not important. This figure indicates that those non adopters now are more interested to have in the future.(Table 4. 5).

Table 4.6. Shortage of money

Attributes	adopters		Non adopters		Total		Chi-square
	Freq	%	Freq	%	Freq	%	
No	18	58.06	25	28.09	43	35.83	8.98***
Yes	13	41.94	64	71.91	77	64.17	

Source: survey result

The study found that about 85.8 % of the sample respondents have their own private house. The figure was 87.1 and 85.39 percent of the adopters and non adopters of DRWH technology have their own private house respectively .This result indicates that respondents having their own private house are encouraged to adopt DRWH practices (table 4.7).

Table 4.7. House ownership type of sample respondents

Category	**adopters**		**Non adopters**		**Total**		**Chi-square**
	Freq	%	Freq	%	Freq	%	
Private	27	87.1	76	85.39	103	85.83	11.1***
Rent	4	12.9	13	14.61	17	14.17	
Relative's house	0	0	0	0	0	0	

Source: survey result

Table 4.8. Government focus to water supply

Attribute	**adopters**		**Non adopters**		**Total**		**Chi-square**
	Freq	%	Freq	%	Freq	%	
Some attention	0	0	47	52.81	47	39.17	6.46**
Less attention	31	100	42	47.19	73	60.83	

Source: survey result

Water is the most important element of life and base of every economic development. Hence, without availability of adequate and safe water supply there will be no development and life at all. In this regard, the respondent's perception towards government role and level of attention to this crucial element in the study area was assessed. The result of the survey revealed that of the total sample respondents 31 (100 %) of the adopters responded that government gives less attention to water supply issue especially for alternative sources of water. While 53 and 47 percent of the non adopters responded that government gives some attention and less attention to water supply problem.

The total sample households (adopters and non adopters) reported that they did not get awareness about the formal way of practicing DRWH as an alternative source of water supply by government bodies. This shows that government policy has traditionally focused on increasing water supply by investing in large scale and centralized projects. But the importance of securing water supply necessitates that all options has to be explored was not taken in to account. Thus the result of the survey study indicates that lack of awareness on DRWH technology affects household decision to adopt DRWH practices highly.

A fast growth rate of population together with large investment in construction and manufacturing sectors causes inadequate water supply in the study area. The survey result indicated that as ground water is the only source of water supply in the study area there is shortage of water supply at source due to over depletion of ground water, quality problem of pipe water, less government focus for water supply problem and technical problems of the municipal in maintenance and mapping of distribution systems of the existing water supply unable to meet the ever increasing demand for water and those are the main driving causes for some households to practice DRWH for getting soft rain water to augment the existing pipe water supply shortage and quality problem.

Table 4. 9. Purpose of rain water

Use of rain water by households	Freq	Percent
For body and cloth washing	61	50.83
For cooking food and drinking	26	21.67
For housekeeping and Toilet flashing	15	12.50
Non users	18	15.00
Total	120	100

Source: Survey Results

From the total sample households, 59, 17 and 9 percents of the respondents were use rain water only during rainy season, full rainy season and partial dry seasons, full rainy and dry seasons respectively. The figure was 25.8 % and 59.2 % for the adopters and non adopters respectively. Full rainy & full dry season, full rainy & partial dry season and only rainy season consumption of rain water was mainly indicated by the adopters of the technology and non adopters having traditional practices respectively. While some 15% of the respondents mainly living in condominiums responded that they did not use rain water because the design of the house did not allow them to use (Table 4.10).

Table 4.10. Duration of rain water use by sample households

Category	adopters		Non adopters		Total	
	Freq	%	Freq	%	Freq	%
Rainy season only	0	0	71	79.77	71	59.17
Full rainy & partial dry season	20	64.52	0	0	20	16.67
Full rainy & full dry seasons	11	35.48	0	0	11	9.17
Rain water non users	0	0	18	20.22	18	15.00

Source: Survey result

The study found that 14, 10 and 3 percents of the respondents were adopting the practice of DRWH because of the presence of shortage of water supply, quality problem of pipe water and to save water tariff respectively. Saving pipe water tariff is not only from the income approach but mainly from the water resource management perspective (i.e freely available rain water has to be utilized). The figure was 100% for the adopter group. With respect to the non adopters the main reasons not to adopt the practice of DRWH are 26, 45 and 29 percent for Shortage of income, lack of awareness about DRWH technology and lack of space in the residential compound for reservoir construction or installation respectively (table 4.11).

Table 4.11. Reasons to adopt and practice DRWH

Main reasons	Freq	Percent
Shortage of pipe water supply	17	14.17
Quality problem of pipe water supply	12	10.00
To save pipe water tariff	4	3.3

Source: Survey results

4.1.3 Tests of the mean and frequency difference of household related variables

The mean values of the continuous variables in both adopters and non adopter groups were compared using t-test is used to indicate the mean difference between groups. That is why the test was used to identify the mean difference between adopters and non adopters. The t- values of 3 continuous variables were computed and in all of these variables the two groups were found to differ significantly (AppendixA3).

Indeed, the two groups may not only differ in terms of quantitative variables, but also in terms of qualitative variables. In this respect, a chi square test was used to examine the existence of statistically significances between the two groups. Accordingly, 8 discrete variables were considered and the two groups were found to be different in terms of 6 variables. More specifically, the chi- square test reveals that 6 discrete variables showed statistically significant differences between the two groups at 5 % probability level (AppendixA4).

4.1.4 Household's decision to adopt DRWH

As it has been mentioned one of the gauges of a community's acceptance of a new idea is availability of information about the technology up to decision to practice and invest on it. It was encouraging to note that in all the situations where the idea of cost of adopting rain water harvesting technologies was introduced and readily accepted provided the cost is within their reach (Ngiggi, 2003).

Thus, the meaning of adoption in this study carries investment in rain water collecting tank. Therefore, in the context of this study, a respondent is said to be adopter if he/she is formally harvesting rain water for domestic uses by investing in above or underground tank. In this regard, 25 % of the respondents were adopters. On the other hand, 75 % of the sample respondents are non adopters. Those non adopters were asked as to why they are not adopting DRWH are most responded that lack of awareness about practicing DRWH in its formal way than its traditional practices consciously. Some of the respondents also reported that they are unable to afford its cost according to this group of respondents, the cost of the technologies were beyond their ability to pay. They also pointed out that there is problem of space within their compound and fear of leakage from septic tank to the water tank. Still there are other respondents believed that, the issue of water supply is not the concern of private households but that of government only.

4.1.5 Non Household Water Users

4.1.5.1 Economics of Urban Water Supply

Water for drinking is a social good, and meeting drinking water requirements is the first and foremost priority because urban areas are growth centers and any reduction in supply of water to urban areas could cause much higher economic losses. However, the investment decisions in the water sector are largely taken on economic and political grounds. And the efforts for water supply faced severe criticism on the cost of pipe water supply which is enormously high; and the environmental impacts of dam construction is always negative and irreversible (Government of India, 2009).

Not only water is becoming a product whose supply will no longer continue to exceed demand, the water authorities are now asking for considerable price increases. This is where rainwater harvesting systems come into the picture. This will make the payback time of installing a rainwater harvesting systems very much shorter. If you consider commercial properties with large roof areas and high consumption of non potable water, the payback can be very much shorter, sometimes only months as we have said before the benefits are much greater than just financial, but also the environmental aspects of retaining water in the system are also very great.

4.1.5.2 Results of descriptive Analysis for non household water users

Table 4.12: distribution of Non household water consumers

Category	**Freq.**	**Percent**	**Cum.**
Government offices	5	25.00	25.00
Schools& Hospitals	5	25.00	50.00
Hotels	5	25.00	75.00
M.Industries	5	25.00	100.00
Total	20	100.00	

Source: Survey result

Of the total non household water users perception on the existing water supply reliability indicates that, 60% of the respondents responded that there is reliable water supply while 40 % responded that there is unreliable water supply. The main reasons for this unreliability was shortage of water supply from source, technical problems of maintenance in distribution systems and imbalance between water supply and the ever increasing demand for water. On top of that, the administration has gives no focus to alternative source of water supply. Hence, all the respondents does not have the awareness about DRWH practices though it is low cost and user friendly technology (Table 4.13).

Table 4.13: Distribution of Respondent's water supply reliability

Perception to water supply reliability	Freq.	Percent	Cum.
Reliable	12	60.00	60.00
Unreliable	8	40.00	100.00
Total	20	100.00	

Source: Survey result

With respect to the monthly water consumption and monthly water tariffs, the water consumption of the non household users ranges from 40 m^3 to 2000 m^3. The average water consumption of those users was 436.75 m^3 with standard deviation of 561.6851m^3. And the average monthly water tariff of the respondent's was 6510 birr with minimum and maximum water tariff paid 1200 and 18000 birr respectively having standard deviation of 5770.766 birr (Table 4.14).

Table 4.14: Monthly water consumption and tariff levels

Category	Obs	Mean	Std. Dev.	Min	Max
Monthly water consumption in M^3	20	436.75	561.6851	40	2000
Monthly water tariff in birr	20	6510	5770.766	1200	18000

Source: Survey result

4.2. Economic analysis

Table4.15 Estimated cost of DRWH tank construction

Category	Volume of tank in M^3	Estimated cost[6]
Household users	10-30	15,000-25,000
Non household users	50-100	52,000-91,000

Source: Survey result

Table 4.16 Water consumption of non household users per annum

Category	Minimum	Maximum
Water consumption in m^3	600	24,000
Water tariff in birr	14,400	216,000

Source: own computation

[6] The estimated investment cost includes 5% maintenance cost in every two years time.

Based on the water consumption level and tariff rates, the non household water users have tremendous advantage from adopting DRWH as an alternative source of water supply for non drinking purposes. In this regard, from the financial saving point of view, an individual institution can save 92,000 – 1, 169,000 birr[7] through the ten year life of the tank. From the water supply problem solving point of view, annually the municipal (MWSSO) can save 600 – 24,000 m^3 water from being used by single institution. Hence, it can reduce ground water over depletion. Moreover, MWSSO can have additional water supply for household's drinking purposes. In this case it can contribute in ensuring short term reliable water supply especially at the peak seasons of the dry period. (Table 4.17)

Table 4.17 Economic analysis of water consumption

Minimum case			**Maximum case**		
Water tariff in ten years time	Cost of tank	Cost saving in birr	Water tariff in ten years time	Cost of tank	Cost saving in birr
144,000	52,000	92,000	1, 260,000	91,000	1,169,000

Source: own computation

4.3. Econometric results for the binary logistic regression model.

A binary logistic regression model was fitted to estimate the effect of hypothesized explanatory variables on the probability of being adopter or not. STATA for windows was used for the econometric analysis.

Prior to the estimation of the model parameters, it is crucial to look in to the problem of multicollinearity or association among the potential candidate variables. To this end, the variance inflation factor (VIF) was used to test the degree of multicollinearity among the continuous variables. The value of the VIF for the variables were found to be small (i.e VIF values less than 10). To avoid serious problem of multicollinearity, it is quite essential to omit the variable with value 10 and more from the logit analysis. The data have no serious problem of multicollinearity

[7] Birr is the Ethiopian currency

(Appendix A5). As a result, 3 continuous explanatory variables were retained and entered in to the binary logistic analysis.

Similarly, the contingency coefficients, which measure the association between various discrete variables based on the Chi-square test, were computed in order to check the degree of association among the discrete variables and the values of contingency coefficients ranges between 0 and 1 with zero indicating no association between the variables and the values close to 1 indicating a high degree of association. Accordingly, the results of the computation reveal that there was no serious problem of association among the discrete explanatory variables (Appendix A6).

A set of 11 explanatory variables (3 continuous and 8 discrete) were included in the model and used in the logistic analysis. These variables were selected based on theoretical explanations and the results of various empirical studies. To determine the best subset of explanatory variables that are good predictors of the dependent variable, the logistic regression was estimated using logistic regression estimation. In this method, all the above mentioned variables were entered in a single step. For estimation of the logistic regression model, some of the explanatory variables that are expected to improve the model fitness were selected and included in the model analysis.

Out of the variables analyzed, the coefficients of ten variables, namely age, marital status, family size, education level of household heads, perception to quality of existing water supply, perception to water supply reliability, social responsibility, perception to importance of DRWH and house ownership and affordability of DRWH were significantly different from zero and out of those eight variables namely age, income, quality of water, reliability of water supply, social responsibility, perception to importance of DRWH, house ownership and affordability of DRWH technology found to be significant to affect the adoption decision of households in the study area. In addition, variable age was found to have negative sign but significant relationship with adoption decision of the household which was similar to the prior expectation. The result of the analysis is presented in (Table 4.18) below

Table 4.18: parameter estimates for binary logit

TECHADOPTION	Coef.	Robust Std. Err.	P>|z|	[95% Conf. Interval]	
REAGE	-.4022989	.1141814	0.000 ***	-.6260511	-.1785467
REMSTATUS	.8981929	1.005724	0.374	-1.07799	2.864375
HHFSIZE	.7831929	.5413756	0.148	-.2772704	1.844883
REEDUC	.2469068	.4234135	0.560	-.5829684	1.076782
HHMINCOME	.0023692	.0006839	0.001***	.0010287	.0037097
REPWSQUALITY	2.894303	1.572604	0.064*	-.1879432	5.97655
REPWSRELIA~Y	4.415927	1.781664	0.013**	-.9239291	7.907924
RESOCIALRE~Y	4.228959	1.301759	0.001***	1.677558	6.78036
REPIMPORTA~H	7.845626	1.208975	0.000***	5.474072	10.21318
REHOUSEOWN~P	4.002415	1.665749	0.016**	.7376073	7.267223
AFFORDABILITY	4.210655	1.249726	0.001***	1.761237	6.66..72
_cons |	-13.30997	9.513943	0.162	-31.95695	5.337019

Source: Results of logit model

Number of obs = 120
Log pseudo likelihood = -13.948813
Wald chi 2(11) = 70.45
Prob > chi 2 = 0.0000
Pseudo R2 = 0.8065

***, ** and * shows significance at 1%, 5% and 10% probability levels, respectively.

The estimates of the binary logit model result shows that the adoption decision of household is determined by the interaction of several potential socio-economic, and other factors. To check measure of goodness of fit in logistic regression analysis, the likelihood ratio test (LR) that follows chi-square distribution with degree of freedom (DF) equal to number of explanatory variables included in the model (Gujarat, 2003). Accordingly, the chi square computed shows that, the model was significant at 1% significance level. This indicates that the null hypothesis stating the coefficients of explanatory variables less the intercept are equal to zero was rejected and the alternative hypothesis of non- zero slope was accepted. The value of chi –square test shows the overall goodness of fit of the model at less than 1% probability level.

Table 4.19. Marginal effect of individual explanatory variables

```
Marginal effects after logit
      y  = Pr(TECHADOPTION) (predict)
         =  .00934122
```

variable	dy/dx	Std. Err.	z	P>|z|	[95% C.I.	]	X
REAGE	-.0039064	.00366	-1.07	0.286	-.011077	.003264	50.5
REMSTA~S	.0080547	.0069	1.17	0.243	-.005461	.02157	.283333
HHFSIZE	.0072708	.00626	1.16	0.245	-.004989	.019531	4.46667
REEDUC	.0016498	.00524	0.31	0.753	-.008628	.011928	1.74167
HHMINC~E	.0000221	.00002	1.36	0.173	-9.7e-06	.000054	5113.33
REPWSQ~Y	.0277714	.0163	1.70	0.088	-.004181	.059724	1.46667
REPWSR~Y*	.1749742	.13866	1.26	0.207	-.096791	.446739	.275
RESOCI~Y*	.2642487	.17392	1.52	0.129	-.07662	.605118	.158333
REPIMP~H*	.40014	.16055	2.49	0.013	.085466	.714814	.475
REHOUS~P*	.1546286	.1665	0.93	0.353	-.171708	.480965	.2
AFFORD~H*	.0696616	.0578	1.21	0.228	-.043628	.182952	.516667

(*) dy/dx is for discrete change of dummy variable from 0 to 1

Source: Results of logit model

Age of household head (REAGE): it is a continuous variable which is significant at 1% significance level and has negative association with adoption decision of households to adopt DRWH. This variable as hypothesized affects the adoption decision of DRWH, in such a way that as the age of the household head increase, they are more reluctant to adopt the practice of DRWH. Thus the negative effect of this variable indicates the influence of age in adopting DRWH practices. This result is consistent with the ideas stated in Dasgupta (1989) and Bekelle and Holden (1998 et al). The marginal effect of age implies that, other things remaining the same, as age of the household head increases the decision to adopt DRWH decrease by a factor of 0.4%.

Household monthly income (HHMINCOME): It is a continuous variable which is found significant at 1 % significance level and affects the decision to participate positively. This means that as respondents monthly income level increase, the degree of decision to participate in DRWH practices gets increase. This is because money increases the investment power of the households' and this is consistent with the prior hypothesis because theory supports this perception that 'income and quantity demanded are positively related in the case of normal goods'. The marginal effect of income implies that, other things remaining the same, as income of the household head increases the decision to adopt DRWH increases by a factor of 0.002 %.

Respondent's perception to quality of the existing water supply (REPWSQUALITY): It is a dummy variable which is found significant at 10 % significance level and affects the decision to participate in DRWH positively. Holding other variables constant, as the respondent perceive that there is poor quality of water supply it will increase a probability of adopting DRWH practice by a marginal factor of 2.8%. The possible justification for this finding was people are conscious enough in their health cases.

Respondent's perception to reliability of the existing water supply (REPWSRELIABILITY): It is a dummy variable which is found significant at 5 % significance level and affects the decision to participate positively. Holding other variables constant, as the respondent perceive that there is unreliable water supply it will increase a probability of adopting DRWH practice by a marginal factor of 17.5%.

Respondent's Social responsibility (RESOCIALRESP): This variable has positive impact on adoption decision of DRWH practices of households and was significant at 1% significant level. Holding other variables constant, as the household head participate in social responsibility it will increase a probability of adopting DRWH practice by a marginal factor of 26.4%. The possible justification for this finding was stated by different literatures as technology dissemination uses local organizations and associations as ways of reaching the whole community. Therefore, being a member of any local organization and/or association could make the household learn and be easily convinced, by another beneficiary household, who is a member in same organization or association and has adopted the technology intervention.

Perception towards importance of domestic roof water harvesting (REPIDRWH): In many literatures such as Nigiggi (2003) and FAO (1994) the issue of technological convenience and acceptance by the users for a proper promotion and adoption of rain water harvesting technology have been stressed. The ease of implementation may be affected by many factors such as availability of local construction materials, ease of maintenance and construction, and so on. The attitude of the users towards the available water harvesting technologies convenience and uses is an important variable for participation decision. It is found, as expected, to be highly significant at 1% significance level and, positively related with the decision of a household to adopt DRWH.

The result of the study coincides with the prior ideas of aforementioned literatures. In this case most of the respondents responded ‘yes’ were adopters of DRWH practices.
The marginal effect indicates that keeping the effect of other variables constant, decision to adopt will increase by 40 % as he/she develops positive attitude towards the use of DRWH practices.

Ownership of a house (OWNHOUSE): It is a dummy variable which is found significant at 5 % significance level and affects the decision to participate in DRWH positively. Holding other variables constant, as the respondent owns a house, it will increase a probability of adopting DRWH practice by a marginal factor of 15.5%. The possible justification for this finding was any investment decision on residences is directly related with ownership of the house. Thus, households having their own house have incentive to adopt the technology.

Affordability of domestic roof water harvesting (AFFDRWH): In many literatures such as Nigiggi (2003) and FAO (1994) the issue of technological convenience and acceptance by the users for a proper promotion and adoption of rain water harvesting technology have been stressed. The extent of adoption may be affected by many factors such as affordability of the technology and so on. Affordability is an important variable for participation decision. It is found significant at 1% significance level and, positively related with the decision of a household to adopt DRWH. The marginal effect indicates that keeping the effect of other variables constant, affordable DRWH technologies will increase household’s decision to adopt by 7 %.

5: CONCLUSION AND RECOMMENDATION

5.1: CONCLUSION

In spite of being water is the basic element of life and urbanization, investment and industrialization in particular and economic development in general depends highly on availability of adequate water supply, water supply in the study area still remains in adequate. The supply of safe and adequate water is below the ever increasing demand for water and still is characterized by insufficient supply. Many people attribute the problem to the growth of population at a rate faster than water supply would guarantee, over depletion of ground water, environmental degradation, poor water resource management and inefficient water use, Insufficient capital for surface water harvesting and ill- thought- out policy . This shortage water supply coupled with rapid population growth and urbanization, has an impact on household water security and profound effect on productivity and the economy in general.

More recently, Ethiopia is under fast economic development, which is characterized by intensive construction works, huge investments in manufacturing and service industries. To accomplish those development activities ensuring adequate water supply in all urban areas is crucial. In this regard, huge investment for surface water harvesting and ground water depletion affects the overall water supply activities. Hence, promoting domestic roof water harvesting practices at individual household levels plays important role. However, there is no study as such which can indicate the status of promotion and adoption of roof water harvesting works across potential users.

This study has tried to look in to the socio-economic and other factors, which can influence the household decision to participate in domestic roof water harvesting. Indeed it will give a brief understanding about perception of existing water supply quality and reliability, perception on the importance of adopting DRWH, the extent of DRWH adoption, purpose of rain water use and duration. In addition to that it was tried to identify factors influencing household’s decision to adopt domestic roof water harvesting as an alternative source of water supply. Therefore the study took 120 households and 20 non household water users, to conduct the survey in which the household respondents were purposively selected from two kefel ketma while the non household users were also purposively selected within the study area. The result of the study understands the following findings:

Eleven variables were hypothesized to explain household decision to adopt domestic roof water harvesting activities to study the factors influencing the adoption of DRWH practices. Evidences from the descriptive analysis indicates that adopters of DRWH have better education standards, enough residential space, have relatively higher income and good understanding about importance of DRWH and quality perception of water supply and most of them did not face financial constraints. Non adopters on the other hand have relatively low level of education in proportion to adopters, have no adequate awareness about importance of DRWH, as compared to adopters they also have financial constraints and no adequate residential plot size. This means non adopters having relatively better education and good understanding about DRWH have financial and space problem to adopt the technology, while some other non adopters have adequate income and space but they have lack of awareness about the technology and even their perception towards water supply is not their issue but the responsibility of government only. On top this; they have lack of access to credit.

The results of binary logit analysis indicated that eight variables at (1%, 5%, 10%) level were found to be significant to affect the adoption decision of households. Age of the household head was found to have negative and significant impact on household decision to adopt DRWH implying that as the age of the household head increases they are reluctant to adopt new technology, household income is significant and positively related variable to affect decision to adopt DRWH practices. Perception to quality and perception to reliability of existing water supply are other significant and positively related variables to affect the decision to adopt DRWH practices. House ownership is positively and significantly correlated to the adoption decision of households to participate in rain water harvesting practices. Social responsibility also have positive and significant effect on adoption decision because social responsibility have a chance of accessing information about new technology and having information can encourage household's to adopt. Attitude towards the importance of DRWH activities is another highly significant and positively related variable to affect the adoption decision of households in rain water harvesting practices.

Last but not least affordability of DRWH technology is significant and positively related variable to affect decision to adopt DRWH practices.

The ultimate sources of fresh water is rain however information gap among community, water professionals, policy makers, international financers and donors are (more interested for large scale projects and programs) some of the reasons for the low level promotion and implementation of DRWH. For instance the Ethiopian water resources management policy didn't point out anything about rainwater harvesting. Target established in the national water sectored development program indicate that the national safe water supply coverage to be 96 percent by the end of 2016. So, It would be a challenging task to the ministry to achieve its plan without considering one of the simplest and affordable technological option; DRWH system.

Recently, the government has started promoting and investing significant amount of money on rainwater harvesting for crop production and domestic water supply proposes, which is an encouraging step to attain the target.

5.2 RECOMMENDATION

Some implications of this study were found to be relevant. The importance of expanding the practice of DRWH is important in solving water supply problems. However, the awareness of the users as well as government bodies is seen to be very low. Based on the main findings of the study, the following recommendations are made.

- Participating users in training, field visits to other adopters practices is an essential element to promote roof water harvesting practices. To accomplish this responsibility, the government has to first equip the pertinent bodies who are working in water supply areas. With necessary knowledge about the uses and means of implementing roof water harvesting works. In addition to providing informal trainings, expanding formal education to the illiterate households enhances promotion and adoption of roof water harvesting practices. Furthermore, inclusion of topics on Integrated Water Resources Management

(IWRM) strategies, which considers “water resources management” rather than “water Management in to the formal education curricula can help to improve awareness level.

- The household’s decision to adopt DRWH was also found to be highly associated with their understanding and knowledge level of roof water harvesting, whether the technologies can be implemented and managed at their knowhow and resource levels. To make users accept and implement roof water harvesting technology, in addition to training and awareness raising works, government and other development organizations should provide technologies appropriate to the specific socio- economic circumstances. Moreover, the individuals, groups as well as policy makers should work towards making the people aware of the uses of roof water harvesting activities to fight against the existing water supply problems.

- Financial status of the household is another key factor explaining the decision behavior of households for participation in roof water harvesting practices. Those households facing financial constraints were not willing to participate in roof water harvesting activities. Working to alleviate the financial constraints of users is, therefore, essential for policy makers and other NGOs to promote rain water harvesting practices in the long run. This can be carried out using various means, one of which is provision of adequate loan with possible minimum interest rates.

- Policy has traditionally focused on increasing water supply by investing in large scale and centralized projects. But the importance of securing water supply necessitates that all options has to be explored. Hence, giving attention to such alternative water sources is paramount important.

- Strengthening intuitional arrangements and provision of revolving funds will increase the decision of households to adopt this alternative source of water supply for domestic use.

- A lot of awareness raising activities should be done on domestic roof water harvesting through water authority and some other administrative bodies of the municipal not only to adopt because of the inadequate water supply but also from the perspective of quality, cost saving and ensuring sustainable water supply at their disposal. So that Building the water literate society.

- The municipal should take the currently adopting households experience and benefits as a base for its advocacy purposes and let the adopters to transfer the benefits they get from adopting DRWH technology to persuade people more.

- Encourage households to substitute rain water for the use of toilet, process water in manufacturing and commercial applications.
- It is also possible and advisable that rain water could use for drinking purposes so that it can reduce the cost of purifying chemicals to make the ground water keep clean and quality for the water supply service.

- Finally, the promotion of DRWH in general is not a cheap option but in areas where both surface and subsurface water resources potential is poor in terms of quantity and quality it will be a best option. DRWH could be made a cheapest option if promoter has used innovative knowledge to cut down cost of construction of the various components of the system.

REFERENCES

Abdulkarim G., 2002. Water harvesting in the Somalia National Regional State of Ethiopia: Workshop on the experiences of water harvesting in Ethiopia: principles and practices. Decmber 28-30. Mekelle. Ethiopia. 34-37p.

Aldrich,J and D. Nelson, 1984. Linear probability, Logit and probit Model: Quantitative applications in the social science. Sera Miller McCun, Sage pub.Inc. University of Minisota and Iowa, London. 47p.

Amemyia,1981. "Qualtitative Response Models." Journal of Economic Literature. (19): 48-53.

Agarwal, A. & Narain, S. (1997) Dying wisdom: the rise, fall and potential of India's traditional water harvesting systems State of India's Environment 4, A Citizen's Report, CSE, New Delhi, 404p.

Befekadu K., (2008), technical performance evaluation of domestic Roof water harvesting schemes in minjar and shenkora woreda. M.sc thesis presented to Addis Ababa University, Department of Geology.

Bekele S. and T. Holden 1998, Resource degradation and adoption of land conservation technologies in the Ethiopian highlands; a case study in Andit Tid, North shewa. The journal of the International Association of Agricultral Economics. 18(3): 244.

Butler, D. S.Ward, F. A. and Memon , (2011), Empirical Performance Assessment of a Large Building Rainwater Harvesting System in the UK, Centre for Water Systems, College of Engineering, Mathematics and Physical Sciences, University of Exeter, north Park Road, Exeter, Devon, EX8 4QF, UK available at: sw278@exeter.ac.uk; f.a.memon@exeter.ac.uk; d.butler@exeter.ac.uk .

Boers, T.M. & Ben-Asher, J. (1982).A review of rainwater harvesting .Agricultural Water Management, volume 5, no 2, p145-158

Bureau of Finance and Economic Devlopment (BoFED), 2011, Mekelle city profile.

Capps. O. Jr. and Kramer. R, A. 1985. Analysis of food stamp participation using qualitative choice models. American Journal of Agricultural Economics. 67:49-59.

Critchley, W. and C. Sieger, 1991. A manual for the design and construction of water harvesting schemes for plant production. FAO, Rome,(17):91.

CTA, (2000). Managing dry land resources. A manual for Eastern and South Africa. 53p.

Dasguptas. 1989, Diffusion of Agricultural Innovations in village India. Department of Sociology and Anthropology, University of Prince Edward Island. Canada, p74-86

Degenet Abebaw, 1999. Determinants of adoption of high yielding varieties of maize in Fimma zone: The case of Mana and Kersa woreda. An M.Sc thesis presented to the school of graduate studies of Alemaya University, 1-2p.

Devi, B.L., Maheshwari, B. & Simmons, B. (2005).Rainwater harvesting for residential irrigation: how sustainable is it in an urban context? Proc. of 12thInternational Conference on Rainwater Catchment Systems, New Delhi, India.

DTU, 2000, Very low cost domestic roof water harvesting in the humid tropics: existing differences, DFID KAR contract R7833, School of Engineering University of Warwick, Report A3. 27p.

DTU, 2002, Very low cost domestic roof water harvesting in the humid tropics: existing differences, DFID KAR contract R7833, School of Engineering University of Warwick, (1). 23p.

Dwivedi. A.K. and Sudhir Singh Bhadauria 2009, ARPN Journal of Engineering and Applied Sciences domestic rooftop water harvesting- a case study, ISSN 1819-6608 VOL. 4, NO. 6.

FAO,1994. Water harvesting for improved crop production. Proceedings of the FAO consultation. Cairo, Egypt, 31-40p

FAO, 1995. Irrigation water development model. Proceedings of the FAO expert consultation. Rome, Italy. 112-115p.

FAO, (2000), the state of food and agriculture. Proceedings of the FAO experts consultation. Rome, Italy. p 133-139

Feder, G. Just, R.E and Zilberman, D. 1985. Adoption of agricultural innovation in development countries. A survey, Economic and Cultural Change, 33. 255-299

Gujarati, D, 1995, Basic Econometrics, 3rd edition, New York, McGraw-Hill.

Gould, J. & Nissen-Peterson, E. (1999).Rainwater catchment systems for domestic supply: design, construction and implementation .Intermediate Technology Publications, London.

Government of India, (2007), Manual on artificial recharging of ground water, Ministry of water resource, central ground water Board, India

Griliches, Z. 1980. R&D and the productivity slow down. American Economic Review.70: 343-480p

Hall, B.H and Khan, B. 2002. Adoption of New Technology. University of California at Berkely. New Economy Handbook.

Habtamu, 1999. Rain water harvesting concepts and issues, proceeding of the annual meeting on soil and water conservation, Addis Ababa, Ethiopia. (2). 24p

Hatibu, N. and F. Mahoo, 2000. Rain water harvesting for natural resources management: A planning guide for Tanzania, Technical handbook, RELMA, (22): 39p.

Heggen, R.J. (2000) Rainwater catchment and the challenges of sustainable development, Water Science and Technology, volume 42, no.1-2, pp141-145.

Hosmer,D. & S. Lemshew,1989. Applied logistic regression. AWiley Inter science publication. Newyork.

IFPRI, 2010, Access to improved water source and sanitation with services, discussion paper Evidence from rural Ethiopia.

Janette W. & Tim van Hattum.(2006) Rainwater harvesting for domestic use, Agrodok-series No. 43, p 6-9

Jeffrey, P. & Gearey, M. (2006). Consumer reactions to water conservation policy instruments. In: Butler, D. & Memon, F.A. (Eds). Water Demand Management.IWA Publishing. London.305-330p.

Julius W, (2000), Rainwater Harvesting Possibilities and Challenges in Kenya, Kenya Rainwater Association, (KRA) p2-5.

José P., 2000 Rainwater harvesting from rooftop catchments, Department of Natural Resources, Higher Institute of Agriculture (ISA), Dominican Republic.

Kebede,Y. Gunjal, K. and Coffin G. 1990. Adoption of new technologies in Ethiopian agriculture: The case of Tegulet-Bulga District, Shoa province. Agricultural Economics. 4: 27-43.

Leisa, 1998. Challenging water scarcity. ILEIA News letter for the low external input and Sustainable agriculture. (14).1.

Maddala G.s, 1983, Limited Dependent and Qualitative Variables in Econometrics, New York, Cambridge University Press

Martinson,D. Ranatunga and A. Gunarante, 2001, Reducing rain water harvesting system cost, Sustainable environmental sanitation and water services, 28th WEDC conference. Calcutta, India. 43p.

Medhin F., 2006 household demand for improved water service in urban areas An MSc Thesis presented to Addis Ababa University

Mekelle Water Supply service office, (MWSSO), 2012 Annual performance report document.

Ministry of Health, 2011, National Drinking Water Quality Monitoring and Surveillance Strategy, may, Federal democratic republic of Ethiopia, Addis Ababa.

Mintesnot B., 2001. The experience of water harvesting in the dry lands of Ethiopia: principles and practices. Workshop on water harvesting in Ethiopia. December 28-30, Mekelle, Ethiopia, 23p.

Mosher, T.A. 1979. An Introduction to Agricultural extension. Singapore University press for the Agricultural Development Council.

Nigigi, N.Stephen, 2003. Rainwater harvesting for improved food security. Nirobi, Kenya

Pindyck, R. and C. Rubinfeld, 1981. Econometric Models and Econometric Forecasts. Second Edition. McGraw- Hill book Co. New York.

Rees, D. 2000. Partially below ground (PBG) tank for rain water storage. Instructions for Manufacture. Development Technology Unit, School of Engineering, University of Warwick. TR-RWH01. 5-7p

Reij,c.,p. Mulder and L. Begemann, (1993). Water harvesting for plant production. A comprehensive Review of the Literature. 3rd printing. The world Bank. Washington, D.C. 1 , 3-13p

Richard R., (2000) A Whole Life Costing Approach for Rainwater Harvesting Systems, Bradford University from: www. SUDSolutions.com

Rogers, E.M 1962 Diffusion of innovation, The Free press, New York. 376p

Roger,M. and F.Shomaker, 1971, Diffusion of Innovations. Second edition. Free press of Glencoe, NewYork.

Rosenberg, N. 1972. Factors affecting the diffusion of technology. Explorations in economic history. 10: 3-33. Reprinted in in 1976, perspectives on Technology, Cambrige: Cambridge University press. 189-212p.

Rundquist, F.M. 1984. Hybrid Maize Diffusion in Kenya. Land University, CWK Gleerup

Shakya, P.B. and Flinn, J.C. 1985. Adoption of modern varieties and fertilizer use on rice in the Eastern Terrai of Nepal. Journal of Agricultural Economics, 36: 409-419.

Sullivan Caroline (2002), Calculating a water poverty index" World Development, Vol. 30, No. 7, pp 1195-1210, Elsevier Science Ltd. Great Britain.

Thomas.T. & Martinson, D.B. (2003). Improving water quality by design. Proc. of 11th International Rainwater Catchment Systems Conference, Texcoco, Mexico.

Thomas, T.H. and Martinson, D.B. (2007). Roof water Harvesting: A Handbook for Practitioners. Delft, The Netherlands, IRC International Water and Sanitation Centre. (Technical Paper Series; no. 49).

Tripathi A. K. and Uma Kant Pandey, 2005, Study of Rainwater Harvesting Potential of Zura Village of Kutch District of Gujarat; Ecology and Environment Division, Forest Research Institute (ICFRE**).**

UN habitat. Rain water harvesting and utilization. Blue drop series, book 2, beneficiaries and capacity building.

Water Resource Development Fund, (WRDF), 2008 ministry of water resources, Appraisal report of Mekelle water supply and sanitation project.

WWW. arpnjournals.com Asian Research Publishing Network, (ARPN, 2006) accessed in January, 2013

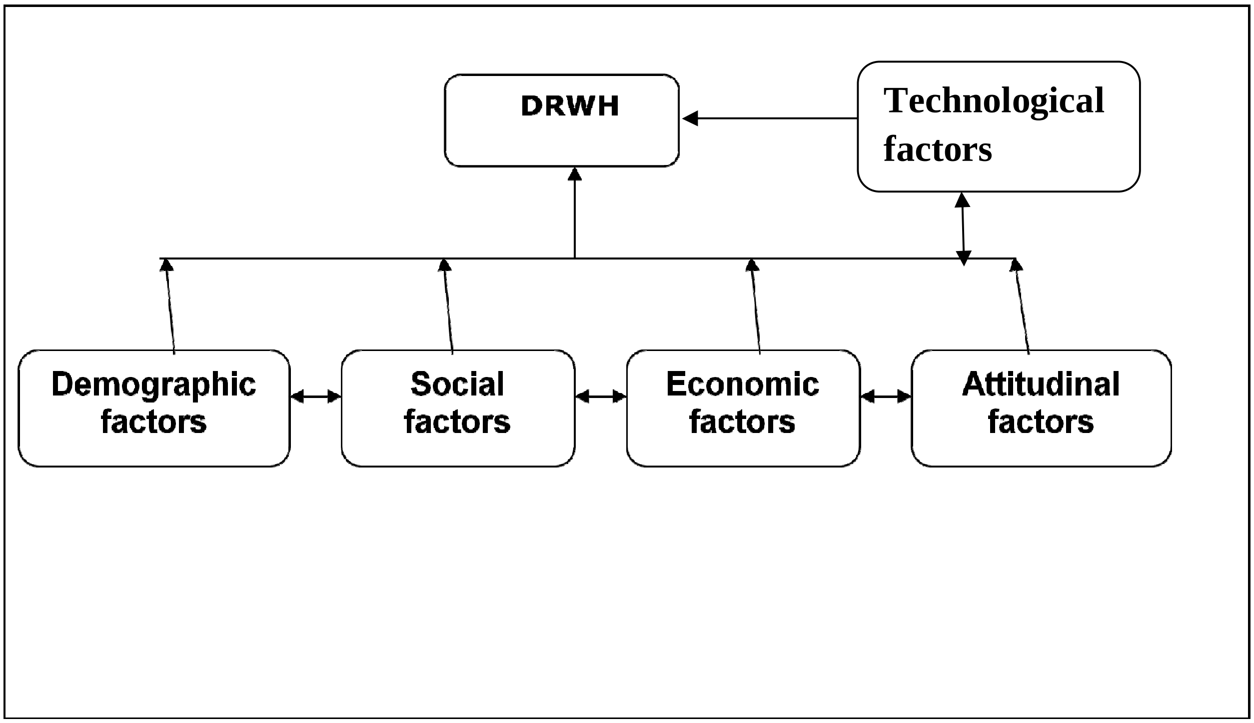
Yapa,L. and C.Mayfeld,(1978). Non-adoption of innovations: evidence from discriminate analysis. Economic Geography. 54(2). 145-156p.

Yimer M. (1992), Factors affecting household water supply and consumption in Nazareth, M.A Thesis (unpublished), department of Geology. Addis Ababa University

APPENDIX

A. Appendix Tables

AppendixA1. Conceptual framework for analysing DRWH adoption behaviour



AppendixA2. Definition of explanatory variables to explain adoption of roof water harvesting

S.No.	Variables code	Definition	Variable type	Expected effect
1	REAGE	Household head age in years	continuous	-
2	REMSTATUS	Respondent's marital status 1= respondent is married , 0= otherwise	dummy	+
3	REEDU	Respondent's education level 0=illiterate, 1= formal education	dummy	+
4	REFSIZE	Households family size in number	continuous	+
5	REMINCOME	monthly income of household	continuous	+
6	REPQW	Respondent's perception to the existing quality of water supply value 1=yes, 0= no	dummy	-
7	REMEMLORG	Households membership in local informal organizations in his kebelle, value 1= yes, 0= no	dummy	+
8	ATITIDRWH	Attitude towards the importance of water harvesting technology 1= if respondent considered important and 0= otherwise	dummy	+
9	REPWSR	Respondent's perception to the existing water supply reliability value 1=yes, 0= no	dummy	-
10	REHOWNERSHIP	1= if respondents have their own house and 0= otherwise	dummy	+
20	AFFTECH	Affordability of DRWH technology 1= if the technology is expensive, & 0= otherwise	dummy	-

Appendix A 3. T- test for mean difference of continuous variables

Continuous variables	Adopters	Non adopters	Total		T- Value
	Mean	Mean	Mean	St.D	
REAGE	48.48	51.20	50.5	7.73	1.6986*
REFSIZE	5.23	4.20	4.47	1.64	-3.089***
REMINCOME	6367.74	4676.40	5113.33	143.31	-5.84***

Source: own computation

*** Significant at 1 % level of significance, * Significant at 10 % level of significance

Appendix A 4. Chi- square test for frequency difference

Dummy variables	score	Adopters		Non adopters		Total		Chi-square
		No	%	No	%	No	%	
REMSTATUS	0	24	77.42	72	80.89	96	80.00	
	1	1	3.23	13	14.62	14	11.67	8.68**
	2	6	19.35	4	4.49	10	8.33	
REEDUC	0	2	6.45	18	20.22	20	16.67	
	1	9	29.03	19	21.35	28	23.33	
	2	6	19.35	20	22.47	26	21.67	3.81
	3	14	45.16	32	35.96	46	38.33	
REPWRQUALITY	1	6	19.35	58	65.17	64	52.50	
	2	25	80.65	31	34.83	56	47.50	19.39***
REPWRRELIABILITY	0	21	67.74	66	74.16	87	72.50	
	1	10	32.26	23	28.84	33	27.50	0.47
RESRESPONSIBILITY	0	22	70.97	79	88.76	101	84.17	
	1	9	29.03	10	11.24	19	15.83	5.46**
REPIMPORTANCEDRWH	0	27	87.10	30	33.71	57	47.50	
	1	4	12.90	59	66.29	63	52.50	26.28***
REHOUSEOWNERSHIP	0	27	87.09	76	85.39	103	85.83	
	1	4	12.91	13	14.61	17	14.17	6.26**
AFFORDABILITY	0	7	22.58	51	57.30	58	48.33	11.10***
	1	24	77.42	38	42.70	62	51.67	

Source: result of chi-square test ** Significant at 5 % level of significance

Appendix A5. VIF of the explanatory variables of adoption decision of DRWH

Variable	VIF	1/VIF
[c] HHFSIZE	2.84	0.351846
[c] REAGE	2.67	0.374936
REMSTATUS	1.65	0.605800
REEDUC	1.43	0.698775
REPWSQUALITY	1.43	0.699675
[c] HHMINCOME	1.35	0.741261
REPIMPORTA~H	1.31	0.765448
AFFORDABILITYDRWH	1.17	0.853841
REPWS RELIAbILITY	1.13	0.886906
REHOUSEOWN~P	1.12	0.889096
RESOCIALRE~Y	1.10	0.910870
Mean VIF	1.56	

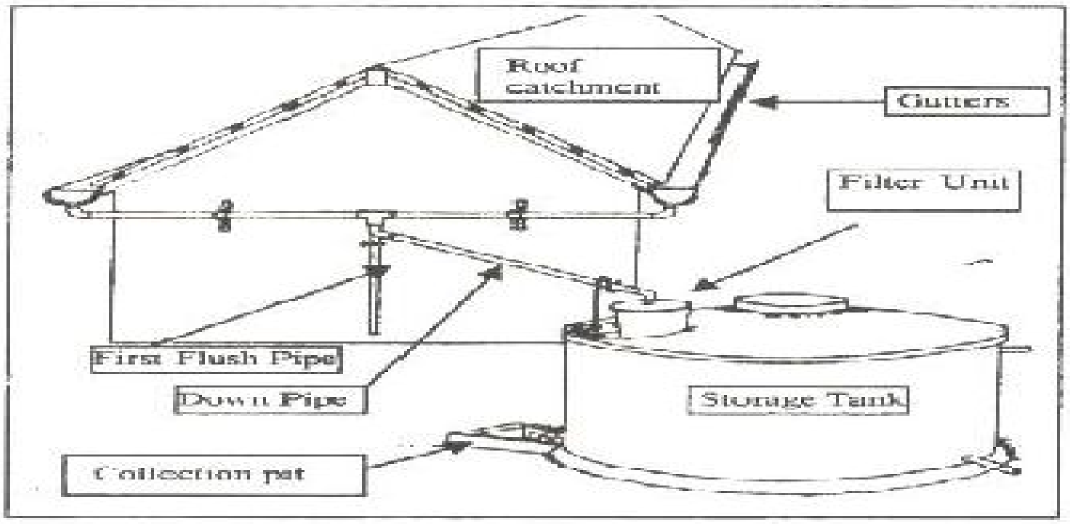
Source: own computation c= shows continuous variables

Appendix A6. Contingency coefficient for discrete variables

	REMSTA~S	REEDUC	REPWSQ~Y	REPWSR~Y	RESOCI~Y	REPIMP~H	REHOUS~P	AFFORD~H
REMSTATUS	1.0000							
REEDUC	0.1998	1.0000						
REPWSQUALITY	0.3058	0.2825	1.0000					
REPWSRELIA~Y	0.0200	-0.0239	-0.0898	1.0000				
RESOCIALRE~Y	-0.1646	-0.0811	-0.0854	-0.0115	1.0000			
REPIMPORTA~H	-0.1688	0.1120	0.0803	-0.1747	-0.0011	1.0000		
REHOUSEOWN~P	0.2124	0.1846	0.2004	0.0653	-0.1027	0.0250	1.0000	
AFFORDABIL~H	0.0119	-0.1157	-0.0312	0.1102	0.0541	0.0852	-0.1001	1.0000

Source: own computation

Appendix A7. Design of above ground roof water harvesting system



Adopted from: Manual on artificial recharging of ground water, 2007

B. Survey Questionnaires

AppendixB1. Assessment of factors affecting household's decision to adopt domestic roof water harvesting practices sample survey questionnaire.

Introduction

Araya Abraha is currently studying at Mekelle University. This research is in partial fulfillment for the award of his MSc in Economics (development policy analysis)

We are asking question to some households in Mekelle city about the current situation of water supply and the extent and use of adopting roof water harvesting practices. So your response will be used as important input to policy makers and officials in their attempt to improve the water supply system of the city.

This interview will take a few minutes and is completely confidential, strictly for academic purpose, honest discussion is the best way ahead of time.

Name of enumerator________________________________

Name of supervisor__________________________________

A. Demographic characteristics (HH preferences)

Q1. Address______________________________

Kefel ketma__________________________

Q2. Marital status of the respondent. ☐ 0) married ☐ 1) single ☐ 2) divorced

Q3.a. Household size ______________________(number)

Q3.b. Household characteristics

No	Name	Age	Sex	R/ship	Education status				
					Illiterate	primary	Secondary	Diploma	Degree & above

B. Social characteristics

Q4, Employment status of household members

S. No	Name	Employment Status			
		Own business	Employed	Unemployed	student
1					
2					
3					
4					
5					
6					
7					
8					

Q5. Do you get tap water at desired time, quantity and quality?

☐ a) yes ☐ b) no

Q6. In relation to its quality, quantity and reliability, how do you rank the current status of water service from the existing source?

1. Quality: 1__Good 2.___Satisfactory 3. ___Poor
2. Quantity 1__Good 2.___Satisfactory 3. ___Poor
3. Reliability 1__Reliability 2.___Unreliability

Q7.Please list the following services in order of importance and in relation the basic problems of the community (list as first, second, etc.)

☐ 1) School ______ ☐ 2) Health _________
☐ 3) Water _______ ☐ 4) Sanitation ______
☐ 5) Road ________ ☐ 6) Electricity ______
☐ 7) Telephone _____

Q8 Is any one of your household member suffered from disease caused by poor pipe water quality such as diarrhea, or typhoid, in the past one year?

☐ 0) No ☐ 1) Yes

Q9.a. Do you have discussion about water issue with the government body?

☐ 0) No ☐ 1) Yes

Q9.b. If yes, what mitigation measures did get priority to solve the problem of water supply?

☐ 1 improve water treatment ☐ 4 HH level adoption of DRWH
☐ 2 Increase borehole ☐ 5 Invest in surface water (Dam)
☐ 3 Renewed distribution systems ☐ 6 other, specify

10.a. Did you have some social position in the community so far?

- [ ] 0) No
- [ ] 1) yes

10.b. If yes, type of responsibility _______________

Q11. What is your attitude in efficient and effective water resource utilization from the perspective of water resource management and leaving a better environment to future generation?

- [ ] 1. _____Very important
- [ ] 2. _____Important
- [ ] 3. _____Less important
- [ ] 4. _____Not responsible
- [ ] 5. _____Don't know

C. Existing water supply and consumption situation

Q12.Do you use the same source of water supply for different household purposes (e.g cooking, drinking, washing etc) throughout the year?

- [ ] 0 No
- [ ] 1 Yes

Q13. a. if Yes, Which source of water supply do you use?

- [ ] 1 Piped water
- [ ] 2 hand-dug well
- [ ] 3 River
- [ ] 4 rain water
- [ ] 5 others, Specify

Q13. b. if no, what type of alternative supply do you use?

- [ ] 1 piped and rain water
- [ ] 2 piped, hand-dug well and rain water
- [ ] 3 piped water and hand-dug well
- [ ] 4 others, Specify

Q14. a. Had there been any water supply interruption from your private connection during the last three months (December-February 2005)?

- [ ] 0 No
- [ ] 1 Yes

Q14. b. If yes, in which season of the year?

- [ ] 1 dry season
- [ ] 2 rainy season
- [ ] 3 both seasons

Q14. c. On average bases, indicate the frequency of this interruption.

- [ ] 1 daily
- [ ] 2 weekly
- [ ] 3 monthly
- [ ] 4 others, specify

Q14. d. On average bases, indicate the duration of interruption.

- [ ] 1 for a week or less
- [ ] 2 for 8 to 15 days
- [ ]
- [ ] 4 for 1 to 2 months
- [ ] 5 for more than two months

3 for 16 to 30 days

Q15.a. Do you have water tanker?

☐ 0 No ☐ 1 Yes

Q15.b. If yes, what is its capacity in liters?

☐ 1. below 1000 liters ☐ 3. 2001-3000 liters

☐ 2. 1001-2000 liters ☐ 4. more than 4000 liters

Q16. Where do you get water from at the time of water supply interruption?

☐ 1 reservoir/tank

☐ 2 buying from neighbors/vendors

☐ 3 buying from public stand pipes

☐ 4 hand-dug well

☐ 5 river, spring

☐ 6 Others, specify

Q17. What is the approximate round trip time taken to fetch water during tap water interruption? Time: ________ hour __________ minutes

Q18. How much water does the household use per day during water supply service interruption? ______________ liters.

Q19.a. How much water does the household use per day when no water supply interruption? ____________ liters.

Q19. b. Do you know the causes for water service interruption?

☐ 0 No ☐ 1 Yes

Q19. C. If yes, what are these causes?

☐ 1 Increase population

☐ 2 shortage of water at the source

☐ 3 lack of enough pressure in distribution system

☐ 4 lack of maintenance

☐ 5 increase household water consumption

Q20. How much, on average, do you pay for your water consumption per month from this source? Average monthly expenditure _________birr

Q21.To what extent do you perceive the current provision of piped water is an issue worth discussion?

☐ 1. __ Very serious

☐ 2. __ Series

☐ 3. __ Less serious

☐ 4. __ Not important

Q22. Who do you think is responsible for water supply?

☐ 1. __Government

☐ 2. __Community

☐ 3. __ Private

4. __ Government and private
5. __ Others (specify)_____

Q23. So far, has the administrative body done enough in solving the problems in the provision of piped water to household?

1. __ A lot attention to the problem
2. __ Some attention to the problem
3. __ Less attention to the problem
4. ___No attention at all

D. Attitude towards adoption of DRWH

Q24. Do you have the knowhow about DRWH?

0 No 1 Yes

Q25.If yes, how would you describe the level of information that is publicly available about roof water harvesting?

1. Too much information
2. Sufficient information
3. Insufficient information
4. No information

Q26. a. Do you have the experience of practicing roof water harvesting?

0 No 1 Yes

Q26. b. If yes, which way did you adopt roof water harvesting?

0 Informal (Traditional) 1 Formal

Q26. c. If it is formal, what type of roof water harvesting technology you adopt?

0 above ground tank 1 underground tank

Q26.d. What type of container do you use for roof water harvesting?

1 pot, Jarican, barrel,
4 steel made tank
2 concrete tank
5 others, specify __________
3 PVC, Roto

Q26. e. If yes, what is the capacity of the tank?

1 Below 2000 liters
4 6000 -8000 liters
2 2000 -4000 liters
5 above 8000 liters
3 4000 -6000 liters

Q26. f. If yes, what is the initial investment cost of the tank?

1. below 3000 birr
2. 3000-5000 birr
3. 5000-7000 birr
4. above 7000 birr

Q26. g. If yes, how long did you harvest roof rain water formally?

1 for one - three years
4 for four - five years
2 for two - three years
5 for five - six years

☐ 3 for three - four years ☐ 6 above six years

Q26. g. If yes, for which purposes(s) you usually use roof rain water?

☐ 1 for drinking ☐ 4 for bathing & cloth washing

☐ 2 car washing ☐ 5 for Housekeeping & toilet flushing

☐ 3 for cooking ☐ 6 garden and animal watering

Q26. h. If yes, on average bases; indicate the duration of roof rain water use?

☐ 1 for full rainy season only

☐ 2 for full rainy season & partial dry season

☐ 3 for the whole year

Q26. i. If yes, what are the major driving reasons to practice rain water harvesting?

☐ 1 shortage of piped water supply

☐ 2 quality problem of pipe water

☐ 3 health related problems of the hard saline pipe water

☐ 4 To reduce pipe water tariff

☐ 5 other, specify

Q26.j. If no, what is the reason not to practice roof water harvesting?

☐ 1 Because there is adequate pipe water supply

☐ 2 Lack of awareness about the DRWH

☐ 3 Shortage of income for investment in DRWH

☐ 4 Lack of space for Reservoir placing/construction

☐ 5 Lack of credit

☐ 6 Lack of advocacy from government bodied (MWSSO)

☐ 7 The perception that water supply is up to the government

☐ 8. Others, specify__________

Q26. k. what is your opinion on the importance of practicing roof water harvesting?

☐ 1. Very important to adopt ☐ 3. Important to adopt

☐ 2 .less important to adopt ☐ 4. not important to adopt

Q27. Do you agree that domestic roof water harvesting will solve the problem of Mekelle water supply?

☐ 0 No ☐ 1 Yes ☐ 3. Don't know

E. Economic characteristics

Q28. House ownership status

☐ 1 Private owned ☐ 2 rented ☐ 3 others, specify ________

Q29. House ownership registration type that you have?

- [ ] 1. Nebar tehezto
- [ ] 2.Lease
- [ ] 3. Association (Mahebrat)
- [ ] 4. Condominium

Q30. How much is the residential plot size in sqm? __________

Q31. Type of occupation and monthly income of family members

S. No	Occupation						Monthly income (Birr)
	Government	NGOS	Business		Agriculture	Daily laborer	
			Owner	employed			
1							
2							
3							
4							
5							
6							
7							

Total: ____________________ (birr/month)

Q32.a. Does the household have any source of income other than those explained above?

- [ ] 0. No
- [ ] 1. Yes

Q32.b what is the monthly total expenditure of the household __________________ (birr/month)

Q33. Do you think shortage of drinking water have negative impact on the economic welfare of the community?

- [ ] 0. No
- [ ] 1. Yes
- [ ] 2. Don't know

Q34. If yes, in what way does it affect?

- [ ] 1. Affecting health
- [ ] 2. Affecting productivity
- [ ] 3. Affecting investment
- [ ] 4. Others (specify)____

Q35. If the household didn't adopt DRWH formally, what is/are the main reason not to adopt in its formal way?

- [ ] 1. Perception to adequate water supply
- [ ] 2. Financial problem
- [ ] 3. Lack of DRWH awareness
- [ ] 4. Space problem
- [ ] 5. Others, Specify__________

Q36.a. Did you face shortage of money to construct DRWH?

☐ 0) No ☐ 1) Yes

Q36.b. If yes, what will be the possible solution to the shortage?

☐ 1. Borrowing from bank ☐ 2. Borrowing from friends

☐ 3. Government revolving funds ☐ 4. Other sources, specify

Q37.a. Did you have access to credit?

☐ 0) No ☐ 1) Yes

Q37.b. If yes, is the credit service is adequate to your need?

☐ 0) No ☐ 1) Yes

Q37.c. If No, what kind of problems did you faced?

☐ 1) Administrative problem ☐ 2) collateral problem

☐ 3) low amount ☐ 4) High interest rate

☐ 5) Others specify ☐ 6. Don't know

F. Technological factors

Q38.a. Did you easily get materials for roof water harvesting tank construction in the market?

☐ 0) No ☐ 1) Yes

Q38.b. If yes, what type of tank do you prefer?

☐ 1) Concrete cement tank ☐ 2) plastic tank ☐ 3) steel made tank

Q38.c.Is the price is affordable in relation to the existing water supply problem?

☐ 1) Yes ☐ 2) No ☐ 3. Don't Know

Q39. Did you easily get skilled labor for roof water harvesting tank construction in the market?

☐ 1) Yes ☐ 2) No ☐ 3. Don't Know

G. Different proxy variables (wealth)

Q40. a. Does the household have shower room?

☐ 0 No ☐ 1 Yes

Q40. b. If yes, how many? ____________ (number)

Q40. C. Please state the frequency of bathing of your household member.

☐ 1 daily ☐ 4 every week
☐ 2 every two days ☐ 5 every two week or more
☐ 3 every three days

Q41. a. Do you have toilet room?

☐ 0 No ☐ 1 Yes

Q41. b. If yes, what type of toilet do you have?

☐ 1 flushing toilet ☐ 3 dry pit latrine
☐ 2 flushing by tin ☐ 4 flush and flushing by tin

Q41. c. If you have a flush toilet, indicate the number ___________

Q42. Do you have cloth washing machine?

☐ 0 No ☐ 1 Yes

Q43. On the average, indicate the frequency of cloth washing.

☐ 1 every three days ☐ 4 every month
☐ 2 every week ☐ 5 others, specify ____________
☐ 3 every two weeks

Q44.a. Do you have automobile?

☐ 0 No ☐ 1 Yes

Q44.b. If you have automobile, where do you get it washed?

☐ 1 inside the compound
☐ 2 in a garage
☐ 3 others, specify _________________

Q44.c. If the automobile is washed inside your compound state the frequency of washing.

☐ 1 daily ☐ 4 once a week
☐ 2 three times a week ☐ 5 others, specify ___________
☐ 3 twice a week

Q44.d. How much water do you need to wash the automobile at a time? __________ liters.

Q45. a. Do you have any garden in your compound?

☐ 0 No ☐ 1 Yes

Q45. b. If yes, how often do you water it?

☐ 1 weekly or less ☐ 3 every month
☐ 2 every two weeks ☐ 4 others, specify ____________

Q45.c. How much water at a time do you use when watering your garden? ____________ liters.

Q46.a. If you have domestic animals in your compound, please answer the following questions.

Sr. no	**Types of animal**	**Number of animals**	**Frequency of watering**	**Amount of water consumed at a time**	**Place of watering**	
					Dry season	**Rainy Season**
1	Cow/ox					

2	Sheep/goat					
3	Horse/mule					
4	Donkey					
5	Others					

Total: _____________liters/month

N.B

46.b. Write the number of frequency of watering from the following choices.

- ☐ 1. Twice a day
- ☐ 2. Once a day
- ☐ 3. Every two days or more

Appendix: B2. Assessment of factors affecting institution's to adopt roof water harvesting practices sample survey questionnaire.

Introduction

Araya Abraha is currently studying at Mekelle University. This research is in partial fulfillment for the award of his MSc in Economics (development policy analysis)

We are asking question to some institutions in Mekelle city about the current situation of water supply service and the extent of adoption of roof water harvesting practices. So your response will be used as important input to policy makers and officials in their attempt to improve the water supply system of the city.

This interview will take a few minutes and is completely confidential, strictly for academic purpose, honest discussion is the best way ahead of time.

Name of enumerator________________________________

Name of supervisor__________________________________

A. Institutional information

Q1. Name of institution, ______________________________

Address___________________________________

Kefel ketma _______________________________

Q2.Type of institution: ☐ 1. Governmental offices ☐ 2.institutions (education, health) ☐ 3.Commercial business (hotels) ☐ 4. Industries

Q3, Focus group characteristics

S. No	Name	Age	Sex	Educational Status	Employment Status			
					business Owner	Employed		
						Manageri al	G. service	expert
1								
2								
3								

B. Existing water Supply situation

Q4. Do you get tap water at desired time, quality and quantity?

☐ 0) No ☐ 1) yes

Q5.a. In relation to its quality, quantity and reliability, how do you rank the current status of water supply service?

1. Quality: 1__Good 2.___Satisfactory 3. ___Poor
2. Quantity 1__Good 2.___Satisfactory 3. ___Poor
3. Reliability 1__Reliable 2.___Unreliable

Q5.b. What is your level of satisfaction with the existing water supply?

☐ 1 Very high ☐ 3 Medium
☐ 2 High ☐ 4 Low

Q6. a. Had there been any water supply interruption from your private connection during the last three months (December – February)

☐ 0 No ☐ 1 Yes

Q6. b. If yes, what are these major problems? (List them in the order of their importance)

____

____

Q6. C. What measures, do you think, should be taken to solve these major problems?

____

____

Q6.d. Who do you see as responsible for water supply in Mekelle, and who is able to bring about change in practices?

____

____

Q7.Please list the following services in order of importance and in relation to basic problem of the community? (list as first, second, etc.)

1) School ______ 2) Health _________
3) Water _______ 4) Sanitation ______
5) Road ________ 6) Electricity ______
7) Telephone _____

C. Existing water demand situation

Q8. a. Do you use the same source of water supply for different purposes (e.g cooking, drinking, washing, toilet flushing, garden watering etc)?

☐ 0 No ☐ 1 Yes

Q8. b. If no, indicate your alternative source. ____________________________

____

Q9.a. Do you have vehicles in your organization?

☐ 0 No ☐ 1 Yes

Q9.b. If yes, write the number of frequency of washing the vehicles

☐ 1. Daily
☐ 2. Weekly
☐ 3. Monthly or more

Q9. c. If yes, what is your source of water?

☐ 1 Pipe water ☐ 3 rain water
☐ 2 Hand dug well ☐ 4 others, specify ____________

Q9.d. How much water approximately at a time do you use for car washing? ____________ liters.

Q10. a. Do you have any garden in your compound?

☐ 0 No ☐ 1 Yes

Q10. b. If yes, how often do you water it?

☐ 1 weekly or less ☐ 3 every month
☐ 2 every two weeks ☐ 4 others, specify ____________

Q10. c. If yes, what is your source of water?

☐ 1 Pipe water ☐ 3 rain water
☐ 2 Hand dug well ☐ 4 others, specify ____________

Q10. d. How much water approximately at a time do you use when watering your garden? ____________ liters.

Q10.e. What is your monthly pipe water consumption?___________________M^3

Q11. How much, on average, do you pay for your water consumption per month from pipe source? Average monthly expenditure _________birr

D. Perception towards domestic roof water harvesting practices

Q12.a. Have you had experiences of domestic roof rain water harvesting?

☐ 0. No ☐ 1. Yes

Q12.b. If Yes or No state the main reasons behind to practice or not to practice domestic roof rain water harvesting?

Q13. What is your opinion on the importance of practicing/adopting domestic roof rain water harvesting?

Q14. In what ways could domestic roof rain water harvesting be used?

Q15. Do you think domestic roof rain water harvesting can help Mekelle's water needs in general?